

**NOTICE !**

**ALL DRAWINGS  
ARE LOCATED  
AT THE END OF  
THE DOCUMENT**

**PROPOSED SURFACE WATER  
INTERIM MEASURES/  
INTERIM REMEDIAL ACTION PLAN  
AND DECISION DOCUMENT**

**903 PAD, MOUND, AND  
EAST TRENCHES AREAS**

**OPERABLE UNIT NO. 2**

**U S DEPARTMENT OF ENERGY**

**Rocky Flats Plant  
Golden, Colorado**

**ENVIRONMENTAL RESTORATION PROGRAM**

**26 September 1990**

**Volume I - Text**

*EXHIBIT-2  
VOL I  
10/23/90  
SA*

**ADMIN RECORD**

**PROPOSED SURFACE WATER  
INTERIM MEASURES/  
INTERIM REMEDIAL ACTION PLAN  
AND DECISION DOCUMENT**

**903 PAD, MOUND, AND  
EAST TRENCHES AREAS**

**OPERABLE UNIT NO. 2**

U S DEPARTMENT OF ENERGY

Rocky Flats Plant  
Golden, Colorado

**ENVIRONMENTAL RESTORATION PROGRAM**

**26 September 1990**

**Volume I - Text**

REVIEWED FOR CLASSIFICATION/UCN:  
By F J Curran U-WU  
Date 10-1-91

**PROPOSED SURFACE WATER INTERIM MEASURES/INTERIM REMEDIAL ACTION PLAN  
AND DECISION DOCUMENT**

**903 PAD, MOUND, AND EAST TRENCHES AREAS  
OPERABLE UNIT NO 2**

**ROCKY FLATS PLANT  
GOLDEN, COLORADO**

**26 SEPTEMBER 1990**

**Prepared by  
EG&G, Inc  
Rocky Flats Plant  
Golden, Colorado 80401**



## TABLE OF CONTENTS

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
	EXECUTIVE SUMMARY	EX-1
1	INTRODUCTION	1-1
1 1	Background	1-2
1 2	IM/IRA Plan Organization	1-3
2	SITE CHARACTERIZATION	2-1
2 1	Site Description and Background	2-1
2 1 1	Location and Facility Type	2-1
2 1 2	Operable Unit 2 Description	2-1
2 1 2 1	903 Pad Area	2-3
2 1 2 2	Mound Area	2-5
2 1 2 3	East Trenches Area	2-5
2 1 3	Surrounding Land Use and Population Density	2-6
2 2	Affected and Sensitive Environment	2-9
2 2 1	Physical Environment	2-9
2 2 2	Regional and Local Hydrogeology	2-10
2 2 2 1	Alluvial Materials	2-10
2 2 2 2	Bedrock Materials	2-14
2 2 3	Site Hydrology	2-16
2 2 3 1	Surface Water	2-16
2 2 3 2	Ground Water	2-17
2 2 4	Ecology	2-20
2 2 5	Sensitive Environments and Endangered Species	2-21
2 2 6	Wetlands	2-22
2 2 7	Historic Sites	2-23
2 3	Contaminants -- Description and Sources	2-23
2 3 1	Background Characterization	2-23
2 3 2	Ground-Water Contamination	2-24
2 3 2 1	Volatile Organic Contamination	2-24
2 3 2 2	Inorganic Contamination	2-25
2 3 3	Soil Contamination	2-29
2 3 4	Sediment Contamination	2-31
2 3 4 1	Woman Creek Drainage	2-31
2 3 4 2	South Walnut Creek Drainage	2-33
2 3 5	Surface Water Contamination	2-34
2 3 5 1	Surface Water Stations Southeast of 903 Pad Area	2-34
2 3 5 2	Upper South Walnut Creek	2-37
2 3 5 3	Seeps at the East Trenches Areas	2-38
2 3 6	Air Contamination	2-38
2 3 7	Summary of Contamination	2-38
2 4	Analytical Data	2-39
2 5	Site Conditions That Justify an IRA	2-40

## TABLE OF CONTENTS (cont.)

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
3	IDENTIFICATION OF INTERIM REMEDIAL ACTION OBJECTIVES	3-1
3 1	Scope of Interim Measures/Interim Remedial Action	3-1
3 2	Interim Remedial Action Schedule	3-1
3 3	Compliance with Applicable or Relevant and Appropriate Requirements (ARARs) and Protection of Human Health and the Environment	3-1
3 3 1	Ambient or Chemical-Specific Requirements	3-3
3 3 1 1	Safe Drinking Water Act Maximum Contaminant Levels (MCLs) and MCL Goals	3-4
3 3 1 2	Ambient Water Quality Criteria	3-4
3 3 1 3	Colorado Surface and Ground-Water Quality Standards	3-4
3 3 1 4	RCRA Ground-Water Protection Standards	3-5
3 3 1 5	Protection of Human Health and the Environment	3-5
3 3 2	Locational Requirements	3-6
3 3 3	Performance, Design, or Other Action-Specific Requirements	3-6
4	IDENTIFICATION AND ANALYSIS OF IM/IRA ALTERNATIVES	4-1
4 1	Surface Water Collection and Treatment Alternatives	4-1
4 1 1	Surface Water Collection Technologies	4-2
4 1 2	Surface Water Treatment Technologies	4-6
4 2	IM/IRA Alternative Evaluation Process	4-9
4 2 1	Effectiveness	4-9
4 2 2	Implementability	4-10
4 2 3	Costs	4-10
4 3	Evaluation of the IM/IRA Surface Water Collection System	4-10
4 3 1	Surface Water Collection by Diversion at the Sources	4-11
4 3 1 1	Description	4-11
4 3 1 2	Effectiveness	4-18
4 3 1 3	Implementability	4-18
4 3 1 4	Costs	4-20
4 4	Evaluation of Surface Water Treatment Technologies	4-20
4 4 1	Suspended Solids Removal	4-20
4 4 1 1	Cross-Flow Membrane Filtration	4-20
4 4 1 2	Granular Media Filtration	4-26
4 4 2	Radionuclides and Metals Removal	4-31
4 4 2 1	Cross-Flow Membrane Filtration	4-31
4 4 2 2	Ion Exchange	4-36
4 4 3	Organic Contaminant Removal	4-41
4 4 3 1	Activated Carbon Adsorption	4-41
4 4 3 2	Ultraviolet (UV) Peroxide Oxidation	4-46
4 4 3 3	Air Stripping with Off-Gas Treatment	4-50

## TABLE OF CONTENTS (cont )

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
5	COMPARATIVE ANALYSIS	5-1
5 1	Introduction	5-1
5 2	Comparison of Technologies	5-1
6	PROPOSED IM/IRA	6-1
6 1	Summary	6-1
6 1 1	Surface Water Collection	6-1
6 1 2	Surface Water Treatment	6-3
6 1 2 1	Suspended Solids and Radionuclide Removal	6-5
6 1 2 2	Organic Containment Removal	6-9
6 1 2 3	Effluent Discharge	6-9
6 2	Operation and Maintenance	6-9
6 2 1	Surface Water Collection	6-9
6 2 2	Cross-Flow Membrane Filtration	6-10
6 2 3	Activated Carbon	6-10
6 3	Additional Documents	6-11
6 4	Treatability Studies	6-11
7	ENVIRONMENTAL EFFECTS OF THE PROPOSED INTERIM REMEDIAL ACTION	7-1
7 1	Air Quality	7-1
7 2	Water Quality	7-4
7 3	Terrestrial Impacts	7-5
7 4	Archaeology and Historic Sites	7-8
7 5	Short- and Long-Term Land Productivity	7-9
7 6	Personnel Exposures - Routine Operations	7-9
7 6 1	Worker Exposure Risks	7-11
7 6 2	Site Employee Exposure Risks	7-14
7 6 3	Risks from Exposure to Members of the Public	7-16
7 7	Personnel Exposure - Accident	7-17
7 8	Commitment of Resources	7-19
7 9	Transportation Impacts	7-20
7 10	Cumulative Impacts	7-22
8	ENVIRONMENTAL EFFECTS OF THE ALTERNATIVES	8-1
8 1	Environmental Effects of No Action	8-1
8 1 1	Environmental Quality	8-1
8 1 2	Personnel Exposure	8-2
8 1 3	Transportation	8-2

## TABLE OF CONTENTS (cont )

<u>SECTION</u>	<u>TITLE</u>	<u>PAGE</u>
8 2	Environmental Impacts of Alternative 2	8-2
8 2 1	Environmental Quality	8-2
8 2 2	Personnel Exposure	8-3
8 2 3	Transportation	8-3
8 3	Summary	8-3
9	REFERENCES	9-1

### APPENDICES

APPENDIX A	Data Tables, Operable Unit No 2
Table A-1	Background Ground-Water (Second Quarter 1989) Tolerance Interval Upper Limits Maximum Detected Value
Table A-2	Background Surface Water (Second Quarter 1989) Tolerance Interval Upper Limits or Maximum Detected Value
Table A-3	Background Sediment Tolerance Interval Upper Limits or Maximum Detected Value February 1989
Table A-4	Background Geologic Materials Tolerance Interval Upper Limits Maximum Detected Value 1989
Table A-5	Volatile Organic Compounds Detected in Unconfined Ground Water Second Quarter 1989
Table A-6	Volatile Organic Compounds Detected In Ground-Water Maximum Concentrations
Table A-7	Dissolved Metals Above Background in Ground Water
Table A-8	Inorganics Above Background in Ground Water
Table A-9	Dissolved Radionuclides Above Background in Ground Water
Table A-10	Volatile Organic Compounds Detected In Soils
Table A-11	Semi-Volatile Organic Compounds Detected in Soils
Table A-12	Total Metals Above Background in Soils
Table A-13	Total Radionuclides Above Background in Soils
Table A-14	Volatile Organic Compounds Detected in Sediments
Table A-15	Total Metals Above Background Sediments
Table A-16	Total Radionuclides Above Background in Sediments

## TABLE OF CONTENTS (cont )

APPENDIX B	Surface Water Sampling Results, Operable Unit No 2
Appendix B-1	Volatile Organic Compounds
Appendix B-2	Dissolved Metals
Appendix B-3	Total Metals
Appendix B-4	Other Inorganic Compounds
Appendix B-5	Dissolved Radionuclides
Appendix B-6	Total Radionuclides
APPENDIX C	Surface Water Sampling Results, Summary Tables Operable Unit No 2
APPENDIX D	Federal Facility Agreement and Consent Order Milestone Schedule, Operable Unit No 2
Table D-1	Federal Facility Agreement and Consent Order Milestone Schedule, Operable Unit No 2
APPENDIX E	ARAR Tables for Surface Water Contaminants
Table E-1 1	Chemical-Specific ARARs for Compounds and Elements Detected Above Background in Surface Water at Operable Unit No 2
Table E-1 2	Chemical-Specific ARARs for Compounds and Elements Detected Above Background in Surface Water at Operable Unit No 2
Table E-1 3	Chemical-Specific ARARs for Compounds and Elements Detected Above Background in Surface Water at Operable Unit No 2
Table E-1 4	Chemical-Specific ARARs for Compounds and Elements Detected Above Background in Surface Water at Operable Unit No 2
Table E-2 1	Analysis of Chemical-Specific ARARs Pertinent to Surface Water Operable Unit 2 IM/IRA Options
Table E-2 2	Analysis of Chemical-Specific ARARs Pertinent to Surface Water Operable Unit 2 IM/IRA Options
Table E-2 3	Analysis of Chemical-Specific ARARs Pertinent to Surface Water Operable Unit 2 IM/IRA Options
Table E-2 4	Analysis of Chemical-Specific ARARs Pertinent to Surface Water Operable Unit 2 IM/IRA Options
Table E-3	Analysis of Probable Action-Specific ARARs for Remedial Actions at Operable Unit 2
APPENDIX F	Flow Weighted Maximum Concentration Calculation Spreadsheet
Table F-1	Flow Weighted Maximum Concentrations

## LIST OF FIGURES

<u>FIGURE</u>	<u>TITLE</u>	<u>PAGE</u>
2-1	Location of Rocky Flats Plant	2-2
2-2	Operable Unit No 2 Remedial Investigation Areas and Solid Waste Management Units	2-4
2-3	Land Use in the Vicinity of the Rocky Flats Plant	2-7
2-4	Surface Water Drainage Patterns at Rocky Flats Plant	2-11
2-5	Erosional Surfaces and Alluvial Deposits	2-12
2-6	Generalized Stratigraphic Section	2-13
2-7	Potentiometric Surface of Unconfined Ground-Water Flow System	2-19
2-8	Operable Unit No 2 Carbon Tetrachloride Isopleths for the Unconfined Ground-Water Flow System	2-26
2-9	Operable Unit No 2 Tetrachloroethene Isopleths for the Unconfined Ground-Water Flow System	2-27
2-10	Trichloroethene Isopleths for Unconfined Ground Water Flow	2-28
2-11	Surface Water and Sediment Monitoring Stations	2-32
4-1	Operable Unit No 2 Surface Water Monitoring Stations	4-3
4-2	Operable Unit No 2 Detail Plan of Surface Water Stations SW-59, SW-60, SW-61	4-4
4-3	Operable Unit No 2 Location of Proposed Surface Water Collection and Treatment Facilities	4-12
4-4	Cross-Flow Membrane Filtration System	4-23
4-5	Granular Media Filtration Unit	4-29
4-6	Ion Exchange Treatment System	4-37
4-7	Carbon Adsorption Treatment Unit	4-42
4-8	UV/Peroxide System	4-47
4-9	Air Stripping With Vapor and Liquid-Phase Carbon Adsorption	4-52
6-1	Proposed IM/IRA Treatment System Process Flow Diagram	6-4

## TABLE OF CONTENTS (cont )

### LIST OF TABLES

<u>TABLE</u>	<u>TITLE</u>	<u>PAGE</u>
4-1	Basis for Design of Surface Water Treatment Plant	4-7
4-2	Surface Water Flow Data for SW-59	4-13
4-3	Surface Water Flow Data for SW-61	4-14
4-4	Design Flows and Average Annual Withdrawal Rates for Surface Water Diversion and Collection System	4-16
4-5	Assumed Costs for Surface Water Diversion and Collection Systems	4-21
4-6	Assumed Costs for Cross-Flow Membrane Filtration Process	4-27
4-7	Estimated Costs for Granular Media Filtration Treatment Unit	4-32
4-8	Assumed Costs for Ion Exchange Treatment System	4-40
4-9	Assumed Costs for Granular Activated Carbon Treatment System	4-45
4-10	Assumed Costs for UV Peroxide Oxidation Treatment System	4-51
4-11	Assumed Costs for Air Stripping with Vapor and Liquid Phase Granular Activated Carbon	4-55
5-1	Comparative Analysis of Technologies	5-2
8-1-A	Summary Comparison of Potential Impacts of Proposed Action and Alternatives	8-4
8-1-B	Summary Comparison of Potential Impacts of Proposed Action and Alternatives	8-5

## GLOSSARY OF ACRONYMS

<u>ACRONYM</u>	<u>MEANING</u>
ARARs	Applicable or Relevant and Appropriate Requirements
AWQC	Ambient Water Quality Criteria
BAT	Best Available Technology
BDAT	Best Demonstrated Available Technology
BDL	Below Detection Limits
CAA	Clean Air Act
CCl <sub>4</sub>	Carbon Tetrachloride
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CEARP	Comprehensive Environmental Assessment and Response Program
CEDE	Committed Effective Dose Equivalent
CEQ	Council of Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CHCl <sub>3</sub>	Chloroform
CMS/FS	Corrective Measures Study/Feasibility Study
CRDL	Contract Required Detection Limit
CS	Collection System (for Surface Water)
CWA	Clean Water Act
1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCE	1,2-dichloroethene
d/m/g	Disintegrations per Minute per Gram
DOE	Department of Energy
DOT	Department of Transportation
DRCOG	Denver Regional Council of Governments
EE/CA	Engineering Evaluation/Cost Analysis
EIS	Environmental Impact Statement
EP	Extraction Procedure
EPA	Environmental Protection Agency
ER	Environmental Restoration Program
FEMA	Federal Emergency Management Agency
FFACO	Federal Facility Agreement and Consent Order (otherwise known as the Inter-Agency Agreement, IAG)
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FRP	Fiberglass Reinforced Plastic



## GLOSSARY OF ACRONYMS

(continued)

<u>ACRONYM</u>	<u>MEANING</u>
FS	Feasibility Study
ft/ft	Foot Per Foot
ft/yr	Foot Per Year
GAC	Granular Activated Carbon
gal/ft <sup>2</sup> /d	Gallons Per Square Foot Per Day
GOCO	Government Owned, Contractor Operated
GPM	Gallons Per Minute
GPM/ft <sup>2</sup>	Gallons Per Minute Per Square Foot
HEC	Health Effects Criterion
HS&E	Health, Safety and Environment
HSWA	Hazardous and Solid Waste Amendments of 1984
H <sub>2</sub> O <sub>2</sub>	Hydrogen Peroxide
IHSS	Individual Hazardous Substance Site
IAG	Inter-Agency Agreement - the Federal Facility Agreement & Consent Order (FFACO)
IDL	Instrument Detection Limit
IM/IRA	Interim Measures/Interim Remedial Action
IRAP/EA	Interim Remedial Action Plan/Environmental Assessment
IRIS	Integrated Risk Information System
KW	Kilowatt
KW-HR	Kilowatt-Hour
LCF	Latent Cancer Fatality
LDR	Land Disposal Restrictions
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
mg/kg	Milligrams Per Kilogram
mg/l	Milligrams Per Liter
M	Molarity
MDA	Minimum Detectable Activity
NCP	National Contingency Plan
NEMA	National Equipment Manufacturer's Association
NEPA	National Environmental Policy Act of 1969
NPDES	National Pollutant Discharge Elimination System
ORP	Oxidation Reduction Potential
OSA	Operational Safety Analysis
OU 2	Operable Unit No 2
PCE	Tetrachloroethene
pCi/g	picoCuries per Gram

## GLOSSARY OF ACRONYMS

(continued)

<u>ACRONYM</u>	<u>MEANING</u>
pCi/kg	picoCuries per Kilogram
pCi/l	picoCuries per Liter
PEL	Permissible Exposure Limits
PL	Public Law
POTW	Publicly Owned Treatment Works
PPB	Parts Per Billion
PPCD	Plan for Prevention of Contaminant Dispersion
PPM	Parts Per Million
PSI	Pounds Per Square Inch
PWF	Present Worth Factor
QA/QC	Quality Assurance/Quality Control
RAAMP	Radioactive Ambient Air Monitoring Program
RCRA	Resource Conservation and Recovery Act of 1976
RfD	Reference Dose
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RFP	Rocky Flats Plant
RI	Remedial Investigation
SARA	Superfund Amendments and Reauthorization Act of 1986
SCFM	Standard Cubic Feet Per Minute
SDWA	Safe Drinking Water Act
SSHSP	Site-Specific Health and Safety Plan
SW	Surface Water Monitoring Station
TBC	To Be Considered
1,1,1-TCA	1,1,1-trichloroethane
1,1,2-TCA	1,1,2-trichloroethane
TCE	Trichloroethene
TDS	Total Dissolved Solids
TOSCO	The Oil Shale Company
TSCA	Toxic Substances Control Act
UMTRA	Uranium Mill Tailings Remedial Action
USFWS	United States Fish and Wildlife Service
UV	Ultraviolet
VOCs	Volatile Organic Compounds
x/Q	Average Dispersion Coefficient
μ	Micro
μCi/ml	Microcuries Per Milliliter
μg/l	Micrograms Per Liter
μg/kg	Micrograms Per Kilogram

## EXECUTIVE SUMMARY

Water quality investigations have identified the presence of organic and radionuclide contamination of surface water at the Rocky Flats Plant. The subject Interim Measures/Interim Remedial Action (IM/IRA) Plan addresses contaminated surface water located within an area identified as Operable Unit No. 2 (OU 2). There is no immediate threat to public health and the environment posed by surface water contamination because the affected surface water is contained within the plant boundary by existing retention ponds, and is treated to meet the Plant's National Pollutant Discharge Elimination System permit requirements prior to discharge. However, there is a potential threat and the Department of Energy (DOE) is implementing this surface water interim remedial action at the request of the U.S. Environmental Protection Agency (EPA) and Colorado Department of Health (CDH). EPA and CDH consider an interim remedial action for surface water to be a high priority. Another factor in implementing this action is the length of time it will take to complete the investigations and engineering studies necessary to determine the final remedy for OU 2.

In February and March 1990, representatives from DOE, EPA, and CDH met to discuss surface water interim remedial actions at the Rocky Flats Plant site. The result of these meetings was a series of agreements, with the concurrence of all parties, to implement an interim remedial action for the cleanup of contaminated surface water in OU 2. Subsequent meetings were held to agree on schedules for this activity. OU 2 is defined in the Federal Facility Agreement and Consent Order (known as the "Inter-Agency Agreement") and is comprised of several Individual Hazardous Substance Sites that were formerly known in aggregate as the 903 Pad, Mound, and East Trenches Areas. DOE is proposing specific point source locations for the collection of surface water, and that this interim action provide collection and treatment of flows exclusive of those resulting from high precipitation events. As discussed herein, the design flow is approximately 52 gallons per minute (gpm), however, the average annual flow rate should be less than 20 gpm. Of the water collected, approximately 20 percent may be from the Woman Creek drainage. It is proposed that the surface water collected from the Woman Creek drainage be treated and discharged into the South Walnut Creek drainage.

This remedial action will be conducted in accordance with the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984, the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund

Amendments and Reauthorization Act of 1986, the National Environmental Policy Act (NEPA) of 1969, and DOE Order 5440 1C EG&G has prepared this IM/IRA Plan to identify and evaluate surface water interim remedial action alternatives. Based on the evaluations, a preferred surface water collection and treatment system is recommended. DOE will implement this interim remedial action while work progresses on the RCRA Facility Investigation/CERCLA Remedial Investigation (RFI/RI) and RCRA Corrective Measures Study/CERCLA Feasibility Study (CMS/FS) for OU 2.

Having presented the general extent of the contamination within OU 2 and the specific environmental issues associated with surface water contamination, this plan subsequently presents an evaluation of the remedial alternatives with respect to effectiveness, implementability, and costs. Effectiveness includes ability to meet Applicable or Relevant and Appropriate Requirements (ARARs). It must be noted, however, that in accordance with the National Contingency Plan (NCP) and the Inter-Agency Agreement, interim measures need only attain ARARs to the greatest extent practicable.

Surface water will be collected at the seeps (or immediately downstream at confluence points) and at an in-stream location on South Walnut Creek upstream of the existing retention ponds, as this will minimize the amount of water treatment necessary and reduce the potential for further downgradient contamination. Screening of surface water treatment technologies includes evaluation of suspended solids and radionuclide/metals removal by chemical precipitation, granular media filtration, ion exchange, and cross-flow membrane filtration, and organic contaminant removal by granular activated carbon (GAC) adsorption, ultraviolet peroxide oxidation, and air stripping. The chemical precipitation and cross-flow membrane filtration system, together with a GAC adsorption system, is selected as the preferred alternative. Laboratory and field treatability studies are being implemented in order to verify performance of the selected alternative. The current schedule for the field treatability studies calls for installation of a pilot system by March 1991. The field treatability unit will be operated to evaluate performance against chemical-specific ARARs. The results may indicate that it is not practicable to attain all ARARs for the surface water interim remedial action. Final performance requirements for the interim remedial action will require approval by the regulatory agencies. An additional function of the field treatability unit is the characterization and quantification of residuals.

generated by the treatment processes being operated, thus allowing confirmation or modification of assumptions made in this IM/IRA Plan regarding the nature of treatment residuals. Table D-1, Appendix D shows the current surface water IM/IRA milestone schedule contained in the Inter-Agency Agreement.

The remainder of this plan addresses the environmental aspects of this project. Specifically, the environmental and health risks associated with each of the alternatives, including the preferred alternative, are examined. The results of this evaluation illustrate that the potential negative impacts to air and water quality, land, and short- and long-term land productivity, as well as exposure of personnel, are minimal compared to the benefits of the resulting water quality improvements to the surface waters of the area.

## SECTION 1

### INTRODUCTION

Water quality investigations have identified the presence of organic and radionuclide contamination of surface water at the Rocky Flats Plant (RFP). This document addresses the contaminated surface water located within an area identified as Operable Unit No. 2 (OU 2). There is no immediate threat to public health and the environment posed by surface water contamination because the affected surface water is contained within the plant boundary by existing retention ponds, and is treated to meet the Plant's National Pollutant Discharge Elimination System (NPDES) permit requirements prior to discharge. However, there is a potential threat and the Department of Energy (DOE) is implementing this surface water interim remedial action at the request of U.S. Environmental Protection Agency (EPA) and Colorado Department of Health (CDH). EPA and CDH consider an interim remedial action for surface water to be a high priority. Another factor in implementing this action is the length of time it will take to complete the investigations and engineering studies necessary to determine the final remedy for OU 2.

In February and March 1990, representatives from DOE, EPA, CDH met to discuss surface water interim remedial actions at the RFP site. The result of these meetings was a series of agreements, with the general agreement of all parties, to implement an interim remedial action for the clean-up of contaminated surface water in the area designated as OU 2. Subsequent meetings were held to agree on schedules for this activity. OU 2 is defined in the draft Federal Facility Agreement and Consent Order (FFACO) (DOE, 1990a), commonly known as the Inter-Agency Agreement (IAG), and is comprised of several Individual Hazardous Substance Sites (IHSSs) that were formerly known in aggregate as the 903 Pad, Mound, and East Trenches Areas. From these meetings, DOE decided to propose specific point source locations for the collection of surface water, and that this interim action provide collection and treatment of flows, exclusive of those resulting from high precipitation events.

This Interim Measures/Interim Remedial Action (IM/IRA) for surface water at OU 2 will be conducted in accordance with the Resource Conservation and Recovery Act of 1976 (RCRA) as amended by the Hazardous and Solid Waste Amendments of 1984 (HSWA), the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and

Reauthorization Act of 1986 (SARA) and DOE Order 5440 1C DOE and EG&G have prepared this Interim Remedial Action Plan (IRAP) to identify and evaluate remedial action alternatives and to select the preferred interim remedial action for the contaminated surface water This IRAP has been prepared to conform with the requirements for an Engineering Evaluation/Cost Analysis (EE/CA) as defined in the National Contingency Plan (NCP) (FR Vol 55, No 46, 8813, 40 CFR 300 415[b][4]) It also conforms to the National Environmental Policy Act (NEPA) of 1969, as implemented by regulations promulgated by the President's Council on Environmental Quality (CEQ) (40 CFR 1500-1508), and DOE Guidelines (10 CFR 1021, DOE Order 5440 1C and 5400 4, DOE/EV-0132)

## 1 1 BACKGROUND

In March 1987, a Phase I Remedial Investigation (RI) under the Environmental Restoration (ER) Program [formerly known as the Comprehensive Environmental Assessment and Response Program (CEARP)] began at OU 2 The investigation consisted of the preparation of detailed topographic maps, radiometric and organic vapor screening surveys, surface geophysical surveys, a soil gas survey, a boring and well completion program, soil sampling and ground and surface water sampling Phase I field activities were completed at OU 2 during 1987, and a draft RI report was submitted to EPA and CDH on December 31, 1987 (Rockwell International, 1987a) Phase I data did not allow adequate definition of the nature and extent of contamination for the purpose of conducting a feasibility study of remedial alternatives pertaining to contaminated media A draft Phase II RI Sampling Plan that presents the details and rationale for further field work to achieve this objective was submitted to the regulatory agencies in June 1988 (Rockwell International, 1988a) This draft sampling plan was subsequently revised and submitted as a final Phase II RCRA Facility Investigation/Remedial Investigation Feasibility Study (RFI/RIFS) sampling plan in April 1990 (EG&G, 1990a) The plan was approved by EPA in May 1990

A draft IRAP plan for contaminated ground water at OU 2 was submitted in December 1989 (Rockwell International 1989a) The plan was prepared based on limited knowledge of the nature and extent of ground-water contamination Regulatory agency review of the document determined that, although an IM/IRA for ground water is required by the 1989 Agreement in Principle between DOE and CDH, insufficient information on the nature and extent of ground-water contamination exists at this time to pursue effective ground-water

remediation. In order to facilitate early evaluation of the need for an IM/IRA for ground water at OU 2, the final Phase II RFI/RIFS sampling plan incorporates a phased investigation approach. The plan was approved by the regulatory agencies. The phased approach is to investigate alluvial and hydraulically connected bedrock migration pathways first, and then to subsequently investigate ground-water contaminant sources. This will allow planning, design, and implementation of a ground water IM/IRA, if necessary, before completion of the RFI/RI and Corrective Measures Study/Feasibility Study (CMS/FS) for OU 2.

## 1.2 IM/IRA PLAN ORGANIZATION

Section 2 (Site Characterization) of this plan describes the potentially affected environment associated with the proposed IM/IRA and the results of the previous investigation at OU 2. The information included in Section 2 has been derived from the draft RI report and final Phase II RFI/RIFS Sampling Plan.

Section 3 identifies the objectives of the IM/IRA, Applicable or Relevant and Appropriate Requirements (ARARs) and applicable environmental regulations. The objectives and ARARs define the criteria used to identify and evaluate IM/IRA options.

Section 4 identifies technically feasible IM/IRA alternatives that address the objectives and screens these alternatives based on implementability, effectiveness, and costs.

Section 5 summarizes the analysis performed in Section 4, and Section 6 presents the preferred IM/IRA. Recommendations for laboratory and field treatability studies that will verify the performance of the preferred IM/IRA are also presented in Section 6.

Sections 7 and 8 incorporate information regarding the environmental effects of the preferred IM/IRA and other IM/IRA alternatives, respectively. This analysis is intended to provide sufficient information to aid in an evaluation of environmental impacts of the proposed interim remedial action. The scope of the analysis does not include evaluation of the existing operations at the RFP, final remedial actions at OU 2 or subsequent remedial actions at other locations of the RFP. The environmental impacts of plant operation were previously



analyzed in the final Environmental Impact Statement (EIS) (DOE, 1980) This document will become an integrated CERCLA/RCRA -- NEPA document (IM/IRAP/EA) once public comment is received and DOE-Headquarters approves NEPA aspects of the document

Volume II of this IM/IRA Plan contains OU 2 surface water, sediment, ground-water, and soils chemistry data as well as the IM/IRA schedule and a tabulation of ARARs

## SECTION 2

### SITE CHARACTERIZATION

#### 2 1 SITE DESCRIPTION AND BACKGROUND

##### 2 1 1 Location and Facility Type

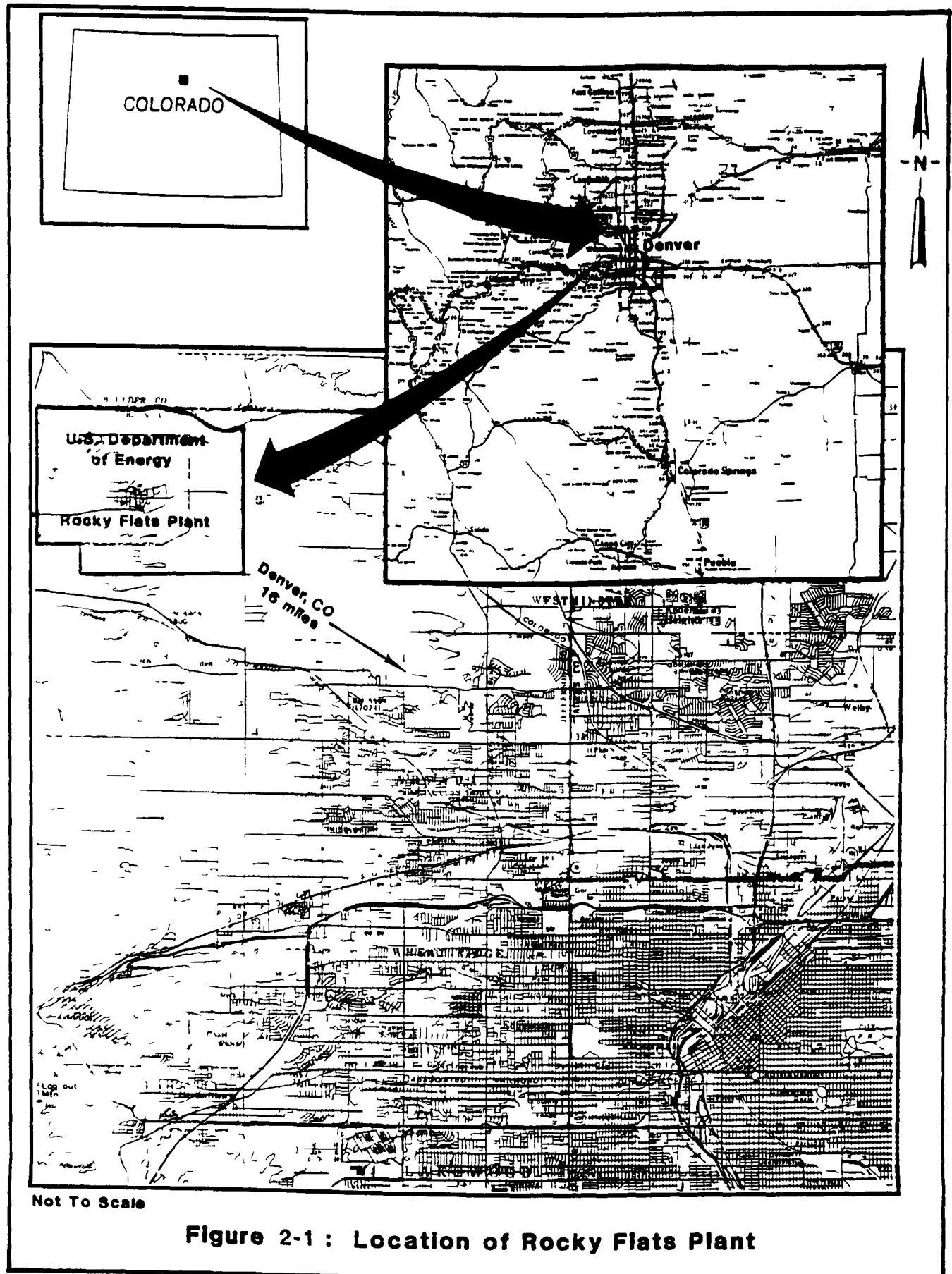
The RFP is located in northern Jefferson County, Colorado, approximately 16 miles northwest of downtown Denver (Figure 2-1). The plant site consists of approximately 6,550 acres of federally-owned land in Sections 1 through 4, and 9 through 15, of T2S, R70W, 6th principal meridian. Plant buildings are located within an area of approximately 400 acres, known as the RFP security area. The security area is surrounded by a buffer zone of approximately 6,150 acres.

The RFP is a government-owned, contractor-operated (GOCO) facility. It is part of a nationwide nuclear weapons research, development, and production complex administered by the Rocky Flats Operations Office of the DOE. The operating contractor for the RFP is EG&G Rocky Flats. The facility manufactures components for nuclear weapons and has been in operation since 1951. RFP fabricates components from plutonium, uranium, beryllium, and stainless steel. Historically, production activities have included metal fabrication, machining, and assembly. Both radioactive and nonradioactive wastes are generated in the process. Current waste handling practices involve on-site and off-site recycling of hazardous materials and off-site disposal of solid radioactive materials at another DOE facility.

The RFP is currently an interim status RCRA hazardous waste treatment/storage facility. In the past, both storage and disposal of hazardous and radioactive wastes occurred at on-site locations. Preliminary assessments conducted under Phase 1 of the Environmental Restoration (ER) Program identified some of the past on-site storage and disposal locations as potential sources of environmental contamination.

##### 2 1 2 Operable Unit 2 Description

There are 20 sites designated as IHSSs which comprise the 903 Pad, Mound and East Trench Areas. These sites are known collectively as OU 2, and are located east-southeast of the RFP (Figure 2-2).



## 2 1 2 1 903 Pad Area

Five sites are located within the 903 Pad Area (Figure 2-2) These sites are

- 903 Drum Storage Site (IHSS Ref No 112),
- 903 Lip Site (IHSS Ref No 155),
- Trench T-2 Site (IHSS Ref No 109),
- Reactive Metal Destruction Site (IHSS Ref No 140), and
- Gas Detoxification Site (IHSS Ref No 183)

Presented below are brief descriptions of each of these sites

- 1 903 Drum Storage Site (IHSS Ref No 112) -- The site was used from 1958 to 1967 to store drums containing radioactively contaminated, used machine cutting oil. The drums, some of which corroded and leaked, contained oils and solvents contaminated with plutonium or uranium. Most of the drums contained lathe coolant consisting of mineral oil and carbon tetrachloride ( $\text{CCl}_4$ ) in varying proportions. However, an unknown number of drums contained hydraulic oils, vacuum pump oils, trichloroethene (TCE), tetrachloroethene (PCE), silicone oils, and acetone (Rockwell International, 1987a). Ethanolamine was also added to new drums after 1959 to reduce the drum corrosion rate. All drums were removed by 1968.  
  
After the drums were removed, efforts were undertaken to scrape and move the plutonium-contaminated soil into a relatively small area, cover it with fill material, and top it with an asphalt containment cover. This remedial action was completed in November 1969. An estimated 5,000 gallons of liquid leaked into the soil during use of the drum storage site. The liquid was estimated to contain 86 grams of plutonium (Rockwell International, 1987a).
- 2 903 Lip Site (IHSS Ref No 155) -- During drum removal and clean-up activities associated with the 903 Drum Storage Site, winds distributed plutonium beyond the pad to the south and east. Although some plutonium-contaminated soils were removed, radioactive contamination is still present at the 903 Lip Site in the surficial soils.
- 3 Trench T-2 Site (IHSS Ref No 109) -- This trench was used prior to 1968 for the disposal of sanitary sewage sludge and flattened drums contaminated with uranium and plutonium.
- 4 Reactive Metal Destruction Site (IHSS Ref No 140) -- This site was used during the 1950s and 1960s primarily for the destruction of lithium metal (DOE, 1986). Small quantities of other reactive metals (sodium, calcium, and magnesium) and some solvents were also destroyed at this location (Illsley, 1978).
- 5 Gas Detoxification Site (IHSS 183) -- Building 952, located south of the 903 Drum Storage Site, was used to detoxify various bottled gases between June 1982 and August 1983.

A Phase I RI has been completed for these five sites. Phase II is planned for this fall.

## 2 1 2 2 Mound Area

The Mound Area is composed of four sites (Figure 2-2) These are

- Mound Site (IHSS Ref No 113),
- Trench T-1 Site (IHSS Ref No 108),
- Oil Burn Pit No 2 Site (IHSS Ref No 153), and
- Pallet Burn Site (IHSS Ref No 154)

These sites are described individually below

- 1 Mound Site (IHSS Ref No 113) -- The Mound Site contained approximately 1,405 drums containing primarily depleted uranium and plutonium contaminated lathe coolant Some drums also contained "Perclene" (Smith, 1975) Perclene was a brand name of tetrachloroethene (Sax and Lewis, 1987) Some of the drummed wastes placed in the Mound Site were in solid form (Rockwell International, 1987b) Cleanup of the Mound Site was accomplished in 1970, and the materials removed were packaged and shipped to an off-site DOE facility as radioactive waste Subsequent surficial soils sampling in the vicinity of the excavated Mound Site indicated 0.8 to 112.5 disintegrations per minute per gram (d/m/g) alpha activity This radioactive contamination is thought to have come from the 903 Drum Storage Site via wind dispersion rather than from the Mound Site (Rockwell International, 1987a)
- 2 Trench T-1 Site (IHSS Ref No 108) -- The trench was used from 1954 until 1962 and contains approximately 125 drums filled with depleted uranium chips (Dow Chemical, 1971) and plutonium chips coated with lathe coolant The drums are still present in this trench
- 3 Oil Burn Pit No 2 Site (IHSS Ref No 153) -- Oil Burn Pit No 2 is actually two parallel trenches which were used in 1957 and from 1961 to 1965 to burn 1,082 drums of oil containing uranium (Rockwell International, 1987b) The residues from the burning operations and some flattened drums were covered with backfill Clean-up operations were performed in the 1970s (Rockwell International, 1987a)
- 4 Pallet Burn Site (IHSS Ref No 154) -- An area southwest of Oil Burn Pit No 2 was reportedly used to destroy wooden pallets in 1965 The types of hazardous substances or radionuclides that may have been spilled on these pallets is unknown Clean-up actions were performed in the 1970s (DOE, 1986)

## 2 1 2 3 East Trenches Area

The East Trenches Area consists of nine burial trenches and two spray irrigation areas (Figure 2-2)

The trench numbers and their respective IHSS designations are

Trench T-3 -- IHSS Ref No 110

Trench T-4 -- IHSS Ref No 111.1

Trench T-5 -- IHSS Ref No 111.2

Trench T-6 -- IHSS Ref No 111 3

Trench T-7 -- IHSS Ref No 111 4

Trench T-8 -- IHSS Ref No 111 5

Trench T-9 -- IHSS Ref No 111 6

Trench T-10 -- IHSS Ref No 111 7

Trench T-11 -- IHSS Ref No 111 8

Trenches T-3, T-4, T-10, and T-11 are located north of the east access road, and trenches T-5 through T-9 are located south of the east access road. The trenches were used from 1954 to 1968 for disposal of depleted uranium, flattened depleted uranium and plutonium-contaminated drums, and sanitary sewage sludge. The wastes have not been disturbed since their burial.

IHSS numbers 216 2 and 216 3 are part of the East Trenches Area and are designated as IHSSs because they were used for spray irrigation of sewage treatment plant effluent. The historical discharge of Pond B-3 was to this spray irrigation area. This practice has been terminated however, and the current Pond B-3 discharge is sent to Pond B-4.

### 2 1 3 Surrounding Land Use and Population Density

The RFP is located in a rural area (Figure 2-3). Approximately 50 percent of the area within ten miles of the RFP is in Jefferson County. The remainder is located in Boulder County (40 percent) and Adams County (10 percent). According to the 1973 Colorado Land Use Map, 75 percent of this land was unused or was used for agriculture. Since that time, portions of this land have been converted to housing, with several new housing subdivisions being started within a few miles of the buffer zone, southeast of the plant site.

A demographic study using 1980 census data shows that approximately 1.8 million people lived within 50 miles of the RFP in 1980 (Rockwell International, 1987b). Approximately 9,500 people lived within five miles of the Plant in 1980. The most populous sector was to the southeast, toward the center of Denver. This sector had a 1980 population of about 555,000 people living between 10 and 50 miles from Rocky Flats. Recent population estimates registered by the Denver Regional Council of Governments (DRCOG) for the eight-county

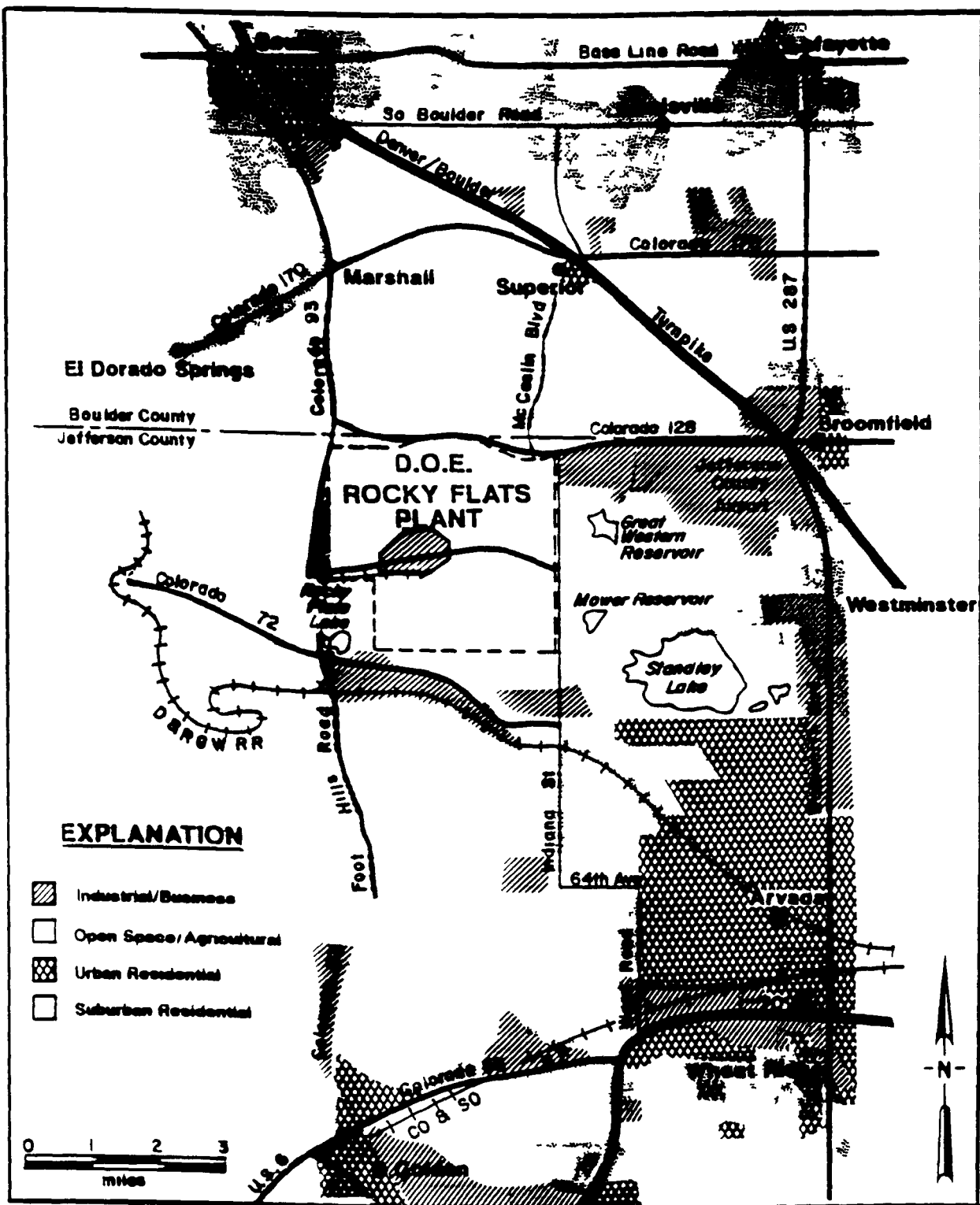


Figure 2-3:  
LAND USE IN THE VICINITY OF ROCKY FLATS PLANT

Denver metro region have shown distinct patterns of growth between the first and second halves of the decade. Between 1980 and 1985, the population of the eight-county region increased by 197,890, a 2.4 percent annual growth rate. Between 1985 and 1989 a population gain of 71,575 was recorded, representing a 1.0 percent annual increase (the national average). The 1989 population showed an increase of 2,225 (or 0.1 percent) from the same date in 1988 (DRCOG, 1989).

There are eight public schools within six miles of the RFP. The nearest educational facility is the Witt Elementary School, which is approximately 2.7 miles east of the Plant buffer zone. The closest hospital is Centennial Peaks Hospital, located approximately seven miles northeast. The closest park and recreational area is the Standley Lake area, which is approximately five miles southeast of the Plant. Boating, picnicking, and limited overnight camping are permitted. Several other small parks exist in communities within ten miles. The closest major park, Golden Gate Canyon State Park, located approximately 15 miles to the southwest, provides 8,400 acres of general camping and outdoor recreation. Other national and state parks are located in the mountains west of the RFP, but all are more than 15 miles away.

Some of the land adjacent to the Plant is zoned for industrial development. Industrial facilities within five miles include the former TOSCO (The Oil Shale Company) laboratory (40-acre site located two miles south and now occupied by Analytica, Inc.), the Great Western Inorganics Plant (two miles south), the Frontier Forest Products yard (two miles south), the Idealite Lightweight Aggregate Plant (2.4 miles northwest), and the Jefferson County Airport and Industrial Park (990-acre site located 4.8 miles northeast).

Several ranches are located within ten miles of the Plant, primarily in Jefferson and Boulder Counties. They are operated to produce crops, raise beef cattle, supply milk, and breed and train horses. According to the 1987 Colorado Agricultural Statistics, 20,758 acres of crops were planted in Jefferson County (total land area of approximately 475,000 acres), and 68,760 acres of crops were planted in Boulder County (total land area of 405,760 acres). Crops consisted of winter wheat, corn, barley, dry beans, sugar beets, hay, and oats. Livestock consisted of 5,314 head of cattle, 113 hogs, and 346 sheep in Jefferson County, and 19,578 head of cattle, 2,216 hogs, and 12,133 sheep in Boulder County (Post, 1989).



## 2 2 AFFECTED AND SENSITIVE ENVIRONMENT

### 2 2 1 Physical Environment

The natural environment of the Plant and vicinity is influenced primarily by its proximity to the Front Range of the Rocky Mountains. The Plant is directly east of the north-south trending Rocky Mountains, with an elevation of approximately 6,000 feet above sea level. The RFP is located on a broad, eastward-sloping plain of overlapping alluvial fans developed along the Front Range. The fans extend about five miles in an eastward direction from their origin in the abruptly rising Front Range and terminate on the east at a break in slope to low rolling hills. The continental divide is about 16 miles west of the Plant. The operational area at the Plant is located near the eastern edge of the fans on a terrace between stream-cut valleys (North Walnut Creek and Woman Creek). The Rocky Flats Alluvium (the deposit of coalescing alluvial fans) is exposed at the surface and consists of a topsoil layer underlain by as much as 100 feet of silt, clay, sand, and gravel.

The RFP is situated in a semiarid region that averages 15 inches of annual precipitation. Forty percent of the yearly total comes in the spring, much of it in the form of snow. Of the balance, 30 percent is accounted for by summer thunderstorms, with the rest occurring in the fall (11 percent) and winter months (19 percent). Average yearly snowfall is 85 inches. Runoff control structures exist to channel surface water from the Plant to monitoring ponds. These structures are sized to accommodate the 100-year storm event which is equivalent to four inches of rain in a six-hour period.

Mineral resources found in the vicinity of RFP include sand, gravel, crushed rock, clay, coal, and uranium. There are no known clay, coal or uranium deposits within the RFP buffer zone, however, these commodities are mined in the region, within 20 miles of the plant. The Schwartzwalder Uranium Mine is located approximately four miles southwest of the RFP. The mine has been the largest producer of vein type uranium ore in Colorado and ranks among the six largest of this type in the United States (DOE, 1980). Active sand and gravel mines lie within the buffer zone boundaries. There is an aggregate processing facility adjacent to the northwest corner of the buffer zone which reopened in 1989. Oil and natural gas production is also active in nearby northwest Adams County and east central Boulder County.

Oil and natural gas activity near Rocky Flats Plant includes oil field developments, pipeline, and production operations. The closest major oil and gas fields are in northwest Adams County (Jackpot and Spindle Fields), and a smaller field occurs in east central Boulder County (Boulder Field). A natural gas pipeline that originates in Wyoming and proceeds across eastern Colorado into Oklahoma is located approximately ten miles north of the Plant in southern Boulder County. Local natural gas pipelines cross the south side of the Rocky Flats Plant. The nearest refinery operation is the Conoco Refinery located in Commerce City about 20 miles east of the Plant. A north-south oriented oil pipeline feeds in to the refinery from fields in northeastern Colorado and southeastern Wyoming (Donaldson and MacMillan, 1980).

There are four main drainages from the Plant property as shown on Figure 2-4. All have intermittent streams which provide drinking water and irrigation water. North Walnut, South Walnut, Rock and Woman Creeks. There are a number of ditches crossing the area as well, conveying water collected off site to other areas, the Plant, Walnut Creek, or Woman Creek. Until late 1974, Plant wastewater had been discharged to Walnut Creek, and until 1975 filter backwash from the raw water treatment plant went into Woman Creek. All process wastewater is now either recycled or disposed through evaporation. Sanitary wastewater is discharged in accordance with the RFP's NPDES permit effluent requirements.

#### 2.2.2 Regional and Local Hydrogeology

The stratigraphic section that pertains to the RFP includes, in descending order, unconsolidated surficial units (Rocky Flats Alluvium, various terrace alluviums, valley fill alluvium, and colluvium) (Figure 2-5), Arapahoe Formation, Laramie Formation, and Fox Hills Sandstone (Figure 2-6). Ground water occurs under unconfined conditions in both the surficial and shallow bedrock units. In addition, confined ground-water flow occurs in deeper bedrock sandstones.

##### 2.2.2.1 Alluvial Materials

The Rocky Flats Alluvium underlies a large portion of the Plant. The alluvium is a broad planar deposit consisting of a topsoil layer underlain by up to 100 feet of poorly stratified silt, clay, sand, gravel and cobbles. Unconfined ground-water flow occurs in the Rocky Flats Alluvium which is relatively permeable. Recharge to

R33014A.PJ--080190

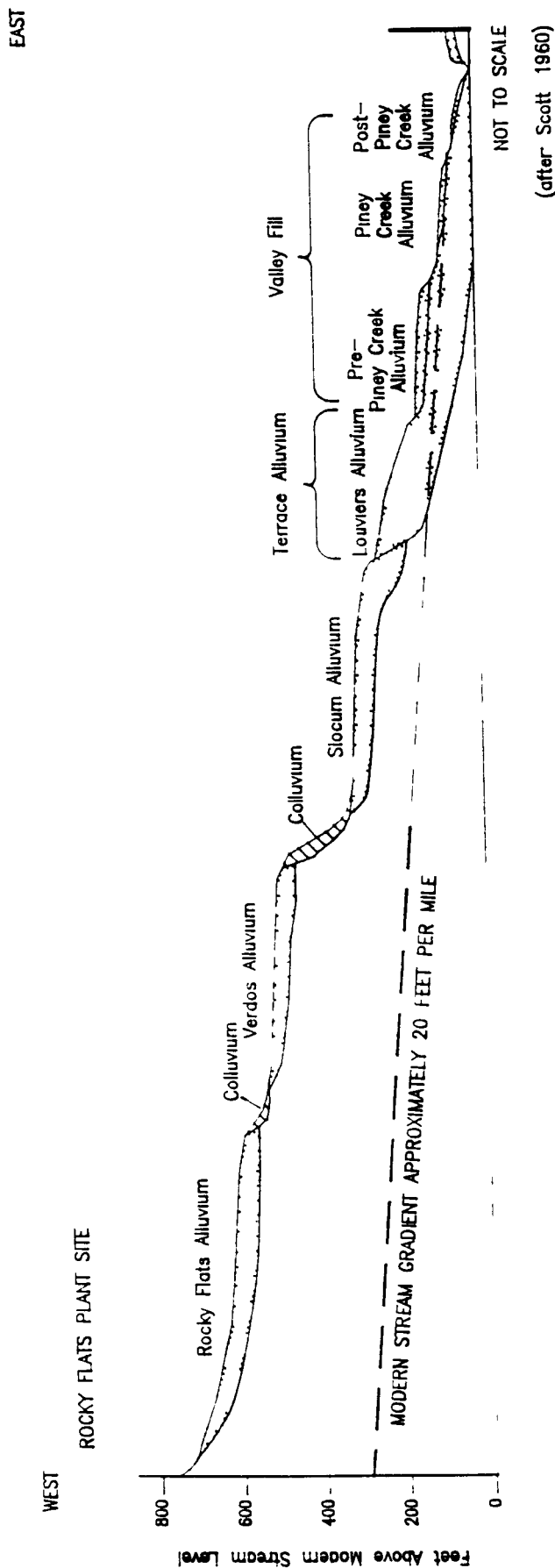


FIGURE 2-5  
 EROSIONAL SURFACES AND ALLUVIAL DEPOSITS  
 EAST OF THE FRONT RANGE, COLORADO

AGE	FORMATION	THICKNESS	GRAPHICS	SUMMARY DESCRIPTION
TERTIARY	Green Mountain	600'		Boulder conglomerate with occasional thin siltstone lenses
	Denver	870'		Yellowish-brown to grayish-olive fluvial tuffaceous claystone siltstone, and sandstone interbedded with conglomerate and olive-gray mudflows
UPPER CRETACEOUS	Arapahoe	270'		Yellowish-gray to yellowish-brown sandstone siltstone; and claystone; discontinuous conglomerate at base
	Laramie	500'		Gray, fine-to-medium-grained sandstone and silty clays; thin coal beds in lower part
	Fox Hills	60'		Tan, fine-to-medium-grained sandstone and sandy shale
	Pierre	± 8000'		Dark gray, silty shale and few thin silty sandstones
	Niobrara	350'		Dark gray, very calcareous shale "Foraminifera abundant (Smoky Hills Member) Light gray, dense, fossiliferous limestone (Fort Hays Member)
	Benton	420'		Brown sandy fossiliferous limestone Dark gray shale with bentonite streaks; thin limestones in middle part; few cone-in-cone concretions in lower part
	Mowry			Dark gray, brittle silty shale (Mowry)
LOWER CRETACEOUS	Dakota Group			
	So Platte	270'		Light gray, fine-to-medium-grained sandstone several dark gray shales in middle part
	Wylie	100'		Light gray, fine-to-coarse-grained, locally conglomeratic sandstone; frequent red and green siltstone interbeds
JURASSIC	Morrison	365'		Gray to greenish-gray to red shale and siltstone thin limestones in middle part; lenticular sandstones in upper and lower part
	Raiston Creek	110'		Light tan siltstone and light red silty shale gypsiferous sandstone at base and locally conglomeratic
TRIASSIC?	Lykins	400'		Red siltstone with two laminated limestones in lower part
PERMIAN	Lyons	120'		Grayish-white fine-to-medium-grained cross-bedded sandstone; conglomeratic lenses frequent
PENNSYLVANIAN	Fountain	1000'		Red, fine-to-coarse-grained sandstone and conglomerate, arkosic; thin tabular red siltstones frequent throughout
PRECAMBRIAN				Gneiss schist, and small granitic intrusions

(modified from LeRoy and Weimer 1971)

FIGURE 2-6  
GENERALIZED STRATIGRAPHIC SECTION

881-903A-PJ-080190

the alluvium is from precipitation, snowmelt, and water losses from ditches, streams, and ponds that are cut into the alluvium. General water movement in the Rocky Flats Alluvium is from west to east and toward the drainages. Ground-water flow is also controlled by sediment drainages in the top of bedrock. The water table in the Rocky Flats Alluvium rises in response to recharge during the spring and declines during the remainder of the year. Discharge from the alluvium occurs at minor seeps in the colluvium that covers the contact between the alluvium and bedrock along the edges of the valleys. OU 2 is situated on a terrace of Rocky Flats Alluvium that thins east of the Plant and does not directly supply water to wells located downgradient of Rocky Flats.

Various other alluvial deposits occur topographically below the Rocky Flats Alluvium in the Plant drainages. Colluvium (slope wash) mantles the valley side slopes between the Rocky Flats Alluvium and the valley bottoms. In addition, remnants of younger terrace deposits including the Verdos, Slocum, and Louviers Alluvia occur occasionally along the valley side slopes. Recent valley fill alluvium occurs in the active stream channels.

Unconfined ground-water flow occurs in these surficial units. Recharge is from precipitation percolation from streams and ditches during periods of surface water runoff, and by seeps discharging from the Rocky Flats Alluvium. Discharge is by evapotranspiration and by seepage into other geologic formations and streams. The direction of ground-water flow is generally downslope through colluvial materials and then along the course of the stream in valley fill materials. During periods of high surface water flow, water is lost to bank storage in the valley fill alluvium and returns to the stream after the runoff subsides.

#### 2.2.2.2 Bedrock Materials

The Cretaceous Arapahoe Formation underlies surficial materials beneath the Plant. This formation is a fluvial deposit composed of overbank and channel deposits. It consists primarily of claystone with some sandstone and is nearly flat lying beneath the Plant (less than a two-degree dip) based on the draft seismic profiling report (Rockwell International, 1989a). The sand bodies within the claystone are composed of fine-grained sands and silts and their hydraulic conductivity is relatively low compared to the overlying Rocky Flats

Alluvium A high resolution seismic reflection survey is ongoing at the Plant to further characterize bedrock geology

The Arapahoe Formation is recharged by ground-water movements from overlying surficial deposits and by leakage from streams The main recharge areas are under the Rocky Flats Alluvium, although some recharge from the colluvium and valley fill alluvium likely occurs along the stream valleys Recharge is greatest during the spring and early summer when rainfall and stream flow are at a maximum and water levels in the Rocky Flats Alluvium are high Ground-water movement in the Arapahoe Formation is generally toward the east, although flow within individual sandstones is not fully characterized at this time Regionally, ground-water flow in the Arapahoe Formation is toward the South Platte River in the center of the Denver Basin (Robson et al , 1981a)

The Laramie formation underlies the Arapahoe and is composed of two units, a thick upper claystone and a lower sandstone The claystone is greater than 700 feet thick and is of very low hydraulic conductivity, therefore, the U S Geologic Survey (Hurr 1976) concludes that Plant operations will not impact any units below the upper claystone unit of the Laramie Formation

The lower sandstone unit of the Laramie Formation and the underlying Fox Hills Sandstone comprise a regionally important aquifer in the Denver Basin known as the Laramie-Fox Hills Aquifer Aquifer thickness ranges from 200 to 300 feet near the center of the basin These units subcrop west of the Plant and can be seen in clay pits excavated through the Rocky Flats Alluvium The steeply dipping beds of these units west of the Plant (approximately a 50-degree dip) quickly flatten to the east (less than two-degree dip) based on preliminary results of the high resolution seismic reflection study (Rockwell International, 1989a) Recharge to the aquifer occurs along the rather limited outcrop area exposed to surface water flow and leakage along the Front Range (Robson et al , 1981b)

Sixteen wells were completed in various zones within bedrock during the 1987 drilling program at OU 2 Although claystone was the most frequently encountered lithology immediately below the alluvium/bedrock contact, interbedded sandy, silty and lignitic units with both gradational and sharp contacts were present as

well All of the bedrock encountered directly beneath surficial materials was weathered, and some saturated sandstones were encountered

### 2 2 3 Site Hydrology

#### 2 2 3 1 Surface Water

Surface water drainage patterns at the RFP are shown on Figures 2-2 and 2-4 A discussion of the major OU 2 surface water features is presented below

#### South Walnut Creek

The headwaters area of South Walnut Creek has been filled during construction of Plant facilities As a result, flow originates from a buried culvert located west of Building 991 Flow in the upper reach of South Walnut Creek is routed beneath Building 991 in a corrugated metal pipe The discharge from the corrugated metal pipe is augmented by flow from a concrete pipe at a point north of the Mound Area The flow from the concrete pipe originates as seepage from the hillside south of Building 991 and flows into a ditch along the slope The combined flow then enters the South Walnut Creek retention pond system Below the retention ponds South Walnut Creek, North Walnut Creek and an unnamed tributary join within the buffer zone Great Western Reservoir is located approximately one mile east of this confluence and is a drinking water source for Broomfield Flow is routed around Great Western Reservoir by the Broomfield diversion canal

The South Walnut Creek retention pond system consists of five ponds (B-1, B-2, B-3, B-4, and B-5) that retain surface water runoff and Plant discharges for flood control, and for monitoring and treatment prior to downstream release All flow in the pond system is eventually retained in Pond B-5, where it is monitored for quality and treated before discharge in accordance with the Plant's NPDES permit (discharge point 006) Ponds B-1 and B-2 are reserved for spill control, surface water runoff, or treated sanitary waste of questionable quality Pond B-3 is used as a holding pond for sanitary sewage treatment plant effluent The historical discharge of Pond B-3 was a spray irrigation system located in the vicinity of the East Trenches This practice has been terminated, however, and the current Pond B-3 discharge is sent to Pond B-4 In addition

to Pond B-3 discharge, Ponds B-4 and B-5 receive surface water runoff from the central portion of the Plant. The surface water runoff received by Pond B-4 is collected by the Central Avenue Ditch and upper reaches of South Walnut Creek. As necessary to meet the Plant's NPDES permit, Pond B-5 water is treated by filtration and activated carbon prior to discharge to South Walnut Creek.

#### Woman Creek

Woman Creek is located south of the Plant, with headwaters in largely undisturbed Rocky Flats Alluvium. Runoff from the southern part of the Plant is collected in the South Interceptor Ditch located north of the creek and delivered downstream to Pond C-2 (see Figure 2-2). Pond C-1 (upstream of C-2) receives stream flow from Woman Creek. Flow in Woman Creek is also influenced by diversion of water from Rocky Flats Lake into the creek by local landowners. The discharge from Pond C-1 is diverted around Pond C-2 into the Woman Creek channel downstream. Water in Pond C-2 is treated and has historically been discharged to Woman Creek in accordance with the Plant's NPDES permit (discharge point 007). However, since October of 1989, treated water is being pumped to the South Walnut Creek drainage and flows off site via the Broomfield diversion canal.

Flow in Woman Creek and the South Interceptor Ditch is intermittent. This has been observed by field investigation crews since 1986 and is indicative of frequent interaction with the shallow ground-water system.

#### 2.2.3.2 Ground Water

Ground water occurs in surficial materials (Rocky Flats Alluvium, colluvium, and valley fill alluvium) and in Arapahoe sandstones and claystones at OU 2. These two flow systems, which are hydraulically connected at shallower portions of the Arapahoe Formation, are discussed separately below.

#### Ground Water in Surficial Materials

Ground water is present in the Rocky Flats Alluvium, colluvium, and valley fill alluvium under unconfined conditions. Recharge to the water table occurs as infiltration of incident precipitation and as seepage from



ditches and creeks. In addition, retention ponds along South Walnut Creek and Woman Creek recharge the valley fill alluvium. Figure 2-7 shows the potentiometric surface of uppermost ground water measured between April 4 and April 8, 1988, and the locations of alluvial and bedrock wells in the vicinity of OU 2.

The shallow ground-water flow system is quite dynamic, with large water level changes occurring in response to precipitation events and stream and ditch flow. For example, between mid-April and September, 1986, water levels in wells 1-86 and 4-86 (completed in valley fill alluvium) dropped more than four and eight feet, respectively. Alluvial water levels are highest during the months of May and June. Water levels decline during late summer and fall, and some wells go completely dry at this time of year. Ground-water flow in the Rocky Flats Alluvium is generally from west to east, following the surface of the claystone bedrock.

Alluvial ground water discharges to seeps, springs, surface water drainages, and subcropping Arapahoe Sandstone at OU 2. Seeps and springs occur along the edge of the Rocky Flats Alluvium terrace (at the alluvium/bedrock contact) and on the side slopes of the terrace. Seeps and springs on the terrace side slopes may be due to thinning of colluvial materials. Ground water in colluvial materials south of the 903 Pad and East Trenches Areas discharges to the South Interceptor Ditch, and ground water in valley fill materials discharges to Woman or South Walnut Creeks.

Hydraulic conductivity values were estimated for surficial materials from drawdown-recovery tests performed on 1986 wells during the initial site characterization and from slug tests performed on selected 1986 and 1987 wells during the Phase I RI (Rockwell International, 1987a). The average ground-water velocities in the Rocky Flats Alluvium, Woman Creek Valley Fill Alluvium, and South Walnut Creek Valley Fill Alluvium are 84 ft/yr, 145 ft/yr, and 20 ft/yr, respectively (Rockwell International, 1987a). These values are based on a horizontal gradient of 0.02 feet/foot (ft/ft), an effective porosity of 0.1, and mean hydraulic conductivities of  $4 \times 10^{-4}$ ,  $7 \times 10^{-4}$  and  $9.5 \times 10^{-5}$  cm/s for Rocky Flats, Woman Creek Valley Fill and South Walnut Creek Valley Fill Alluvium, respectively. The calculations assume year-round saturation. However, as discussed above, portions of the Rocky Flats Alluvium, colluvium, and valley fill alluvium are not continuously saturated. Thus, the shallow ground water must flow at less than the calculated annual average velocities. The reactivity of dissolved constituents could further reduce contaminant migration rates below estimated ground-water velocities.

## Bedrock Ground Water

The majority of ground-water flow in the Arapahoe Formation occurs in the meandering lenticular sandstones contained within the claystones. Ground-water recharge to sandstones occurs as infiltration from alluvial ground water where sandstones subcrop beneath the alluvium and by leakage from claystones overlying the sandstones. Usable ground water occurs in the Arapahoe aquifer. Water in sandstones of the Arapahoe aquifer are used for irrigation, livestock watering, and domestic purposes east of RFP.

There is a strong downward gradient between ground water in surficial materials and bedrock. Vertical gradients range from 0.31 ft/ft between wells 35-86 and 34-86 to 1.05 ft/ft between wells 41-86 and 40-86. These gradients imply a relatively high hydraulic conductivity contrast between the surficial materials and bedrock, which is supported by hydraulic conductivity test results.

Flow within sandstones is regionally west to east. The geometry of the ground-water flow path in the bedrock is not fully understood at this time because it depends upon the continuity of the sandstones and their interconnection. Evaluation of the lateral extent and degree of interconnection of the sandstone units is a primary goal of the Phase II and Phase III Remedial Investigations for OU 2.

Hydraulic conductivity values for Arapahoe sandstones were estimated from drawdown-recovery tests performed in 1986, slug tests performed in 1987, and packer tests performed in 1986 and 1987. The maximum horizontal ground-water flow velocity in sandstone is 75 ft/yr using a hydraulic conductivity of 83 ft/yr, a horizontal gradient of 0.09 ft/ft, and an assumed effective porosity of 0.1.

### 2.2.4 Ecology

Within the Plant boundaries a variety of vegetation thrives. Included are species of flora representative of tall grass prairie, short grass plains, lower montane, and foothill ravine regions, with none being on the endangered species list. It is evident that the vegetative cover along the Front Range of the Rocky Mountains has been radically altered by human activities such as burning, timber cutting, road building, and overgrazing for many years. Since the acquisition of the RFP property, vegetative recovery has occurred as evidenced by

the presence of grasses like big bluestem and sideoats grama (two disturbance-sensitive species) No vegetative stresses attributable to hazardous waste contamination have been identified (DOE, 1980)

The animal life inhabiting the RFP and its buffer zone consists of species associated with western prairie regions The most common large mammal is the mule deer, with an estimated 100 to 125 permanent residents There are a number of small carnivores, such as the coyote, red fox, striped skunk, and long-tailed weasel A profusion of small herbivore species can be found throughout the Plant and buffer zone consisting of species such as the pocket gopher, white-tailed jackrabbit, and the meadow vole (DOE, 1980)

Commonly observed birds include western meadowlarks, horned larks, mourning doves, and vesper sparrow A variety of ducks killdeer, and red-winged blackbirds are seen in areas adjacent to ponds Mallards and other ducks frequently nest and raise young on several of the ponds Common birds of prey in the area include marsh hawks, red-tailed hawks, ferruginous hawks, rough-legged hawks, and great horned owls (DOE, 1980)

Bull snakes and rattlesnakes are the most frequently observed reptiles Eastern yellow-bellied racers have also been seen The eastern short-horned lizard has been reported on the site, but these and other lizards are not commonly observed The western painted turtle and the western plains garter snake are found in and around many of the ponds (DOE 1980)

## 2.2.5 Sensitive Environments and Endangered Species

The Endangered Species Act of 1973 (Public Law 93-0205), as amended, provides that all federal agencies implement programs for the conservation of listed endangered and threatened species Federal agencies must ensure that actions authorized, funded, or carried out by them will not jeopardize the continued existence of any endangered or threatened species

The U S Fish and Wildlife Service (USFWS) has indicated that the two endangered species of interest in the RFP area are the bald eagle and the black-footed ferret (Rockwell International, 1988d) Prairie dog towns provide the food source and habitat for ferrets Since there are no prairie dog towns in or near the 881

Hillside Area which is near the 903 Pad, Mound and East Trenches, the USFWS has determined that ferrets probably do not exist in the investigation area. Bald eagles are occasional visitors to the area, primarily during migration times. Sightings are rare and little suitable habitat exists on the RFP site other than some perching locations. No nests are found on the RFP site. The proposed action will not adversely affect the bald eagle. The USFWS has concurred with these findings subsequent to a field visit on 6/15/88 (Rockwell International 1988d).

Other animal species of interest that exist in the RFP area include burrowing owls and Swainson's hawks. Cottonwood trees within approximately 1/4 mile of the 903 Pad, Mound, and East Trenches Areas were investigated to determine if any raptor nests exist and none were found. The trees will be reinspected in the spring to ensure that activities do not disturb nesting or raising of young. The nearest population of burrowing owls is approximately two miles to the east. The nearest population of Swainson's Hawks could be in the cottonwood trees in the area of the North Walnut Creek or Rock Creek drainages, north of the 881 Hillside area.

The 903 Pad, Mound, and East Trenches Areas are not used, nor intended for use, as a public or recreational area, nor for the development of any unique natural resource. No unique ecosystems were found at the RFP during extensive biological studies (DOE, 1980).

#### 2.2.6 Wetlands

Initial consultation with the USFWS and the U.S. Army Corps of Engineers was conducted in the spring of 1988. Wetlands at the RFP site were delineated. The proposed action is not located in the delineated wetlands. Aerial photography imagery for the 903 Pad, Mound, and East Trenches Areas was examined for wetlands identification followed by limited site inspection (EG&G, 1990b). Two isolated stands of wetlands vegetation containing common cat-tail (*Typha latifolia*) were located primarily within IHSS 140, where ground water flowing toward the terrace edges emerges as seeps or springs at the contact between the alluvium and bedrock. The two areas are each less than 20 square feet in size.

Linear wetlands areas have been identified along both the Woman Creek and South Interceptor Ditch drainage areas. These drainages collect surface water upgradient from OU 2 and deliver the water to pond C-2 for treatment. Evenly-spaced drop structures along the South Interceptor Ditch have lowered flow velocities, increased sediment accumulation, and created fairly dense linear stands of wetlands. From a point due south of Building 881 and extending to the C-2 Pond, approximately 0.15 acres of wetland are contained within this portion of the South Interceptor Ditch. Wetland species observed were primarily cattails (greater than 95 percent predominance), spike rush (Eleocharis macrostachya) and bullrush (Scirpus americanus). The wetlands function primarily as flow attenuation features with additional minor contributions to wildlife habitat and water quality enhancement. Drainage contribution to the South Interceptor Ditch from OU 2 is minimal.

#### 2.2.7 Historic Sites

The National Historic Preservation Act of 1966 (Public Law 89-665) together with subsequent law amendments (Public Laws 91-243, 93-54, 94-422, 94-458) provides that all federal agencies implement programs for the protection of archeological and historical resources.

The 903 Pad, Mound and East Trenches Areas have been highly disturbed over a number of years. Due to this disturbance and the topographic position of the subject area, the State Office of Archeology and Historic Preservation has determined that this action will not impact cultural resources (Burney, 1989). An archaeological and historical survey of the RFP was conducted between July 18 and August 22, 1988, which determined two sites have potential eligibility to the National Register of Historic Places. However, insufficient information currently exists to make this determination. These two sites are located northwest and southwest of the investigation area and will not be disturbed by the proposed action (Burney, 1989).

### 2.3 CONTAMINANTS -- DESCRIPTION AND SOURCES

#### 2.3.1 Background Characterization

In order to facilitate the interpretation of chemical results in non-background areas, a background characterization program has been implemented to define the spatial and temporal variability of naturally

occurring constituents Fieldwork was conducted in 1989, and a draft Background Geochemical Characterization Report was prepared and submitted to the regulatory agencies on December 15, 1989 (Rockwell International, 1989d) The document summarizes the background data for ground water, surface water, sediments, and geologic materials, and identifies preliminary statistical boundaries of background variability Spatial variations in the chemistry of geologic materials and water were addressed by placing sample locations throughout background areas at the Plant The goal of evaluating temporal variations in water chemistry has not yet been achieved because at least two years of quarterly data are needed

The draft report will be updated in 1990 by incorporation of analytical data that were unavailable in December 1989, including additional rounds of ground-water and surface water samples for which laboratory analyses were not available The information in the draft background geochemical report has been used to preliminarily characterize inorganic contamination at the 903 Pad, Mound, and East Trenches Areas The draft report presents tolerance intervals for surface water, sediment, and various soil lithologies and hydrogeologic units (ground water) The tolerance intervals are statistical ranges of the background analyte concentrations in the various media that represent 95 percent of the population with 95 percent confidence Summary tables of the upper limits of these tolerance intervals are provided in Tables A-1 through A-4 (see Appendix A) for reference

## 2 3 2 Ground-Water Contamination

Ground water at the RFP has been monitored on a routine basis since 1986 Wells have been installed throughout the property and are sampled quarterly The following discussion is based on the resulting data

### 2 3 2 1 Volatile Organic Contamination

Table A-5 (Appendix A) presents all volatile organic compounds (VOCs) with concentrations that are above detection limits in the unconfined ground-water system during the second quarter of 1989 These are the most recent validated data pertaining to the same season for which the background levels were determined Maximum concentrations of volatile organics based on the complete data set (1986-1989 sampling) are summarized in Table A-6 The primary volatile organic ground-water contaminants ( $\text{CCl}_4$ , PCE, and TCE) are

portrayed with isopleths in Figures 2-8 through 2-10 based on second quarter 1989 data for both unconfined alluvial and bedrock wells

The data in Tables A-5 and A-6 confirm the relative dominance of  $\text{CCl}_4$ , PCE and TCE in alluvial and shallow bedrock ground water at OU 2 compared to other volatile organic compounds, and documents occurrences of 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethene (1,2-DCE), and vinyl chloride (all are possible degradation products of the principal contaminants), and 1,1,1-TCA, total-1,2-DCE, 2-hexanone,  $\text{CHCl}_3$ , methylene chloride, acetone and carbon disulfide. The latter four analytes were reported at levels below detection limit and therefore represent only estimated values.

The distribution of the principal contaminants suggests that the 903 Pad is the main source of  $\text{CCl}_4$ , with possible contributions from the northern East Trenches. The Mound Area is the main source of PCE, and TCE occurs throughout OU 2, implying multiple sources. The Phase II Work Plan for this site discusses volatile organic ground-water contamination in further detail (EG&G, 1990a).

#### 2.3.2.2 Inorganic Contamination

##### Major Ions

Major ions and total dissolved solids (TDS) are somewhat elevated above background throughout and downgradient of the 903 Pad, Mound and East Trenches Areas (Table A-7, Appendix A). Total dissolved solids typically ranged between 400 and 1000 milligrams per liter (mg/l), chloride was generally 30-100 mg/l, nitrate was 2-10 mg/l, and most sulfate concentrations were between 10 and 100 mg/l in the second quarter of 1989. In general, major cations were accordingly elevated. The highest concentrations of major ions are in well 29-87 southeast of the 903 Pad, although ground water at the northernmost wells (34-87 and 35-87) was also quite high in TDS (~1000 mg/l).

## Metals

Aluminum, antimony, arsenic, barium, cadmium, chromium, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, strontium, vanadium and zinc exceeded background in one or more wells in the second quarter of 1989. Table A-8 (Appendix A), a summary of multiple sampling events (up to fourteen samples collected from each well during 1987-1989), shows that only a subset of these analytes repeatedly exceed background (upper limit of the tolerance interval) and/or exceed background by a wide margin. The sporadic exceedances of background, and the absence of apparent gradients in metal concentrations with respect to IHSSs, hinders drawing definite conclusions as to whether these constituents are derived from IHSSs (EG&G, 1990a). Section 2.3.5 makes reference to this and other ambiguities in the ground-water chemistry data to the extent that they may be relevant to the surface water interim action plan.

## Radionuclides

Table A-9 (Appendix A) shows that dissolved concentrations of the uranium isotopes (U-234, U-235 and U-238), plutonium, and americium have been above background at OU 2. The maximum concentration for uranium 238 was  $28 \pm 2$  pCi/l in well 12-87 in the 903 Pad Area. Numerous occurrences of uranium at lower concentrations and in wells completed in diverse lithologies demonstrate that the distribution of uranium is not thoroughly delineated at OU 2. With respect to plutonium and americium, results at wells 15-87 and 11-87 were the most elevated (plutonium  $0.522 \pm 0.117$  pCi/l and  $0.199 \pm 0.07$  pCi/l, respectively, americium  $0.831 \pm 0.148$  pCi/l and  $0.06 \pm 0.05$  pCi/l respectively).

## 2.3.3 Soil Contamination

The extent of soil contamination at the 903 Pad, Mound and East Trenches Areas was determined from soil samples collected in 1987 during the Phase I RI. Samples were collected from boreholes drilled in and adjacent to known IHSS locations. Two-foot intervals were composited for organic analyses, and two- to ten-foot intervals were composited for all other analytes. Boreholes were not drilled into sites still containing wastes (the trenches and 903 Pad) due to potential health hazards to field workers and potential for release of waste.



constituents to the environment. The soils data are summarized here because of the potential influences contaminated soils may have on surface water quality. Either direct contributions via overland runoff, or direct influences via ground-water interactions are possible. The discussion is considered preliminary because wastes were not directly sampled and soils data are still being evaluated.

Volatile organic compounds, including PCE, TCE, toluene, 2-butanone,  $\text{CCl}_4$ , acetone and methylene chloride, were reported in samples from the 903 Pad and East Trenches Areas (see Table A-10). Occurrences of total xylenes, ethyl benzene and toluene were also reported for the 903 Pad Area, whereas 1,2-dichloroethane (1,2-DCA), 1,1,1-TCA, and 1,1,2-TCA were reported in an East Trenches borehole. The Mound Area, like other portions of OU 2, contained acetone (hundreds of  $\mu\text{g/l}$ ) and methylene chloride (typically tens of  $\mu\text{g/l}$ ) at concentrations too low to unambiguously demonstrate contamination with these compounds. Other organic constituents in the Mound Area (PCE,  $\text{CHCl}_3$ , 1,2-DCA) were less numerous and at lower levels than at other areas within OU 2. Semi-volatile organic compounds di-n-Butyl phthalate, bis(2-Ethylhexyl) phthalate, and N-nitrosodiphenylamine were detected in numerous boreholes throughout OU 2 (see Table A-11, Appendix A).

Several metals occurred above background in soil samples (aluminum, arsenic, barium, cadmium, calcium, iron, mercury, manganese, lead, antimony, vanadium and zinc), although most exceeded background by less than a factor of two and/or in only one or two samples. Table A-12 (Appendix A) presents maximum metal concentrations in soils.

Plutonium and americium are the principal radionuclide contaminants exhibiting elevated concentrations in soils. Table A-13 (Appendix A) presents maximum radionuclide concentrations in soils at OU 2. Highest concentrations occurred in samples that included the surface. Because many of the surface soil samples were mixed into large composites, the Phase I RI data do not rule out the presence of radionuclides other than plutonium and americium. Cesium-137, tritium, and uranium were detected, albeit at near-background concentrations and in fewer than ten samples. Surface contamination of soils with plutonium and americium was further demonstrated by a recent aerial radiological survey (EG&G, 1989). The radioactivity detected in that survey was associated with known radioactive material storage and handling areas (i.e., the 903 Pad), and was attributed to plutonium, americium, and a uranium decay product. The survey indicated elevated

concentrations of americium in soils east of the 903 Pad Lip Site as high as 97 pCi/g, and by inference from their expected activity ratio, plutonium as high as 500 pCi/g. Subsequent analysis of samples from the area with high americium concentrations indicated plutonium concentrations as high as 457 pCi/g. The cesium-137 activity was at a level consistent with global fallout and not enriched in the Plant area.

#### 2.3.4 Sediment Contamination

Sediments in Woman Creek and South Walnut Creek were sampled in the fall of 1986, and in March and October of 1989. Stations SED-28, SED-29, and SED-25 are located within the South Interceptor Ditch in the Woman Creek drainage (Figure 2-11). SED-30 and SED-31 are seeps on the South Interceptor Ditch berm near station SED-29. SED-27 and SED-26 are along Woman Creek just upstream of Pond C-2. Stations SED-11, SED-12, and SED-13 are located along South Walnut Creek. SED-11 is the most upgradient station, SED-12 is just upstream of Pond B-1, and SED-13 is just downstream of Pond B-5. Stations SED-1 and SED-2 on Woman Creek and an ephemeral tributary, respectively, are both downstream of OU 2, just west of Indiana Street within the boundary of the buffer zone (east of area depicted by Figure 2-11).

##### 2.3.4.1 Woman Creek Drainage

VOCs were detected in samples from the sediments in the Woman Creek drainage (Table A-14, Appendix A). Chloromethane was present at SED-29 (60 µg/kg), and chloroform was reported at SED-31 (18 µg/kg). Several sediment samples contained methylene chloride and acetone at very low concentrations. These compounds were frequently found in associated blanks. SED-30 contained 220 µg/kg acetone at one sampling, but acetone was also present in the blank for this sample and was undetected in two other sampling events for this station in 1989. Acetone and methylene chloride results in this area are believed to be laboratory artifacts. The only other volatile organic compounds detected in the Woman Creek drainage sediment samples were TCE (8 µg/kg) at SED-31 (estimated below detection limits elsewhere), and toluene estimated below detection limit at SED-29 and SED-30.

Of the metals, beryllium, lithium, silver, tin, and zinc were notably elevated above background in the sediment of the South Interceptor Ditch and Woman Creek (Table A-15, Appendix A) Concentrations of silver (as high as 49 mg/kg) are greater than five times the upper limit of the background range at stations SED-25, SED-26 and SED-30 Beryllium was not detected in the background samples (<1.1 mg/kg) but occurs at concentrations ranging from 3.8 to 15.5 mg/kg in all the sediment samples collected from the South Interceptor Ditch and Woman Creek Although tin was not above background (<22.8 mg/kg) at SED-27, SED-28, and SED-31, it occurred in a range from 364 to 1080 mg/kg in stations SED-25, SED-26, SED-29, and SED-30 Concentrations of zinc (as high as 735 mg/kg) are greater than the upper limit of the background range at stations SED-11, SED-28, SED-29, and SED-30

Plutonium was above background at stations SED-1, SED-2, SED-25, SED-26, SED-29, and SED-30, ranging in concentration from 0.06 to 0.85 pCi/g (Table A-16, Appendix A) Contaminated surface soil from the 903 Pad Area, transported primarily by wind, may be the source of this plutonium

#### 2.3.4.2 South Walnut Creek Drainage

The South Walnut Creek sediment monitoring stations include SED-11, SED-12 and SED-13 Only one sample was obtained from each of SED-12 and SED-13 (13 August 1986) Due to prioritization of sampling activities, additional samples were not collected from these stations Table A-14, Appendix A shows that acetone was reported for all three stations and was also associated with laboratory blanks SED-11 was found to contain TCE and 2-butanone at concentrations of 39 mg/kg and 12 µg/kg, respectively All other VOCs were either not detected or reported below detection limits for SED-11, SED-12 and SED-13

As in the Woman Creek drainage, beryllium, lithium, silver, and tin are elevated in the sediments at SED-11 They occurred at concentrations of 2.5, 7.2, 15.0, and 404 mg/kg, respectively Zinc was also notably elevated, occurring at a concentration of 735 mg/kg (the upper limit of the background tolerance interval is 93 mg/kg) Uranium 235 was reported at a concentration of 0.2 pCi/g for SED-11 and americium levels were reported at 0.19 pCi/g and 0.03 pCi/g for SED-12 and SED-13, respectively Plutonium was also found at a concentration of 0.35 pCi/g at SED-12 Wind-dispersed contaminated soils from the 903 Pad and Lip Area may be the source of these radionuclides

### 2 3 5 Surface Water Contamination

Twenty-six surface water and surface seep stations in the vicinity of the 903 Pad, Mound, and East Trenches Areas were sampled during field activities from 1986 through 1990 (see Appendix B). The following discussion is based on all available data because many seeps or stream stations are dry during some samplings. These data have been summarized in Appendix C and compared to ARARs (see Section 3 for ARAR identification). Total radiochemical and metals data, although presented in the Appendix, are not discussed because an assessment methodology that accounts for varying concentrations of suspended solids is still being developed. Surface water monitoring locations are shown on Figure 2-11.

Flowing surface water in drainages was sampled at stations on the South Interceptor Ditch and Woman Creek just upstream of Pond C-2 and at stations upstream of the B-series ponds on South Walnut Creek. The B-series ponds were not sampled for this investigation, as they will be subsequently investigated as part of another operable unit.

The surface water seeps are downslope and southeast of the 903 Pad Area, and downslope and north of the Mound Area and East Trenches Areas. Because surface water at seeps and in streams represents ground-water discharge (intermittent discharge with respect to streams), the surface water compositions are similar to those of local ground water. The data for both media show that PCE, TCE,  $\text{CCl}_4$ , and their degradation products are the principal VOCs, and they show very similar major ion contents as well. However, there is enough variability within stations so that it is not possible to demonstrate surface/ground-water connections on a well-by-well, seep-by-seep basis.

#### 2 3 5 1 Surface Water Stations Southeast of 903 Pad Area

There are several seeps downslope to the southeast of the 903 Pad. Surface water stations established at these seeps in the 903 Pad Lip Area are designated SW-50, SW-51, SW-52, SW-55, SW-57, SW-58, and SW-77. Station SW-50 is closest to the 903 Pad, and SW-57 and SW-52 are south of SW-50. SW-51 and SW-58 are located in a ditch along the road east of SW-50, however, overland flow of seepage from SW-50, SW-52, and SW-57 will also enter the ditch. Water in the ditch passes under the road south of these locations.

through a culvert. The discharge of the culvert is sampled at station SW-55. SW-77 is another seep located on the east side of the road, just north of SW-55. It is noted, therefore, that SW-51, SW-58, and SW-55 are physically connected and likely receive flow from SW-50, SW-52, and SW-57. Farther downgradient stations include seeps at SW-53, SW-62, SW-63, and SW-64, SW-27, SW-30, SW-54, and SW-70 on the South Interceptor Ditch, and SW-26, SW-28, and SW-29 on Woman Creek.

Data for seeps in the vicinity of the 903 Pad Lip Site and farther downgradient at SW-53, SW-63, and SW-64 indicate organic contamination. Contaminants in seeps in the vicinity of the 903 Lip Site include 1,1-DCE, 1,2-DCE,  $\text{CCl}_4$ , TCE, and PCE, with concentrations of  $\text{CCl}_4$  and TCE exceeding  $1000 \mu\text{g/l}$ . 1,2-DCE and TCE are occasionally present at SW-53, low concentrations of  $\text{CCl}_4$  and TCE ( $<20 \mu\text{g/l}$ ) occur at SW-63, and low concentrations of TCE occur at SW-64. Methylene chloride also occasionally occurs in these seeps, but at concentrations near the detection limit, and frequently also occurs in the laboratory blanks. Low and very infrequent concentrations of these and other volatiles occur at seep SW-62 as well as at stations along the South Interceptor Ditch. The water-quality data for stations along the South Interceptor Ditch and Woman Creek do not provide unambiguous evidence of contamination, however, the volatile organic concentrations in the upgradient seeps suggest that a solvent plume within alluvial ground water is migrating to the southeast, which is consistent with the alluvial ground-water flow direction. It is inferred that organic contaminated alluvial ground water approaches the South Interceptor Ditch and Woman Creek.

With respect to inorganic and dissolved radionuclide contamination, there are somewhat elevated concentrations of TDS, major ions, aluminum, strontium, zinc, and uranium at most of these stations. Unlike the absence of volatiles in surface water at stations along the South Interceptor Ditch (SW-70, SW-30, SW-54, and SW-27), all have somewhat elevated uranium concentrations (generally less than  $10 \text{ pCi/l}$  of total uranium). These concentrations are usually above ARAR ( $5 \text{ pCi/l}$ ). Although the 903 Pad Area cannot be ruled out as the source of the uranium, the occurrence of elevated uranium as far upgradient as SW-70 suggests the 881 Hillside Area as a potential source. Alluvial ground water at the 881 Hillside contains levels of uranium above background.

Seeps in the vicinity of the 903 Pad Lip Site (SW-50, SW-53, and SW-54) had detectable plutonium and/or americium during one sampling event in 1989 (two events for SW-53). The samples contained

substantial suspended solids and were not filtered at the time of collection, and surface soils in the vicinity of the seeps are contaminated with radionuclides. Furthermore, total radiochemistry data do indicate notably higher plutonium and americium concentrations than in filtered samples, demonstrating that most of the radionuclides are in a particulate form. Therefore, the local soils represent the most direct potential source for seep contamination. However, there were traces of plutonium in a few ground-water samples (highest concentration at well 15-87,  $0.522 \pm 0.117$  pCi/l) so ground water is also a potential source of radionuclides in seeps, albeit a less significant one.

It is noted that plutonium and americium are essentially insoluble in natural waters, but they can migrate in colloidal form, and colloidal-size particles can pass through  $0.45 \mu\text{m}$  filters such as those used in the previous investigation (Puls and Barcelona 1989). The DOE is currently conducting a study to assess the distribution of plutonium and americium in surface water with respect to suspended solids particle size. The study will include filtration of surface water through three pore sizes, and laboratory analysis for plutonium and americium in the filtered and unfiltered fractions ( $<0.10 \mu\text{m}$ ,  $0.10 \mu\text{m}$  to  $<0.20 \mu\text{m}$ ,  $0.20 \mu\text{m}$  to  $<0.45 \mu\text{m}$ , and  $\geq 0.45 \mu\text{m}$ ). Although this study was not explicitly designed to differentiate colloidal and dissolved radionuclides, and therefore will be unable to quantify colloidal material under  $0.1 \mu\text{m}$ , it will demonstrate whether a significant portion of the radionuclides is between  $0.1$  and  $0.45 \mu\text{m}$  and thereby provide some indication of the importance of colloidal transport. Also, if most of the plutonium is particulate in nature ( $>0.1 \mu\text{m}$  in size), it is likely plutonium can be removed from surface water by unit processes effective at removal of suspended solids, e.g., sedimentation and filtration.

Regardless of the transport mode, total plutonium concentrations occur above background at station SW-29 on Woman Creek (range  $<\text{Minimum Detectable Activity [MDA]}$  -  $315 \pm 115$  pCi/l), and dissolved plutonium was detectable during one sampling event ( $159 \pm 142$  pCi/l). Dissolved plutonium was also detectable at station SW-70 on the South Interceptor Ditch ( $11 \pm 09$  pCi/l), however, the total plutonium concentration was  $0.011 \pm 0.057$  pCi/l during this sampling event, rendering this data questionable. The one datum that exists in the remedial investigation data base indicates total plutonium is not above background in Pond C-2 (dissolved radionuclide data do not exist).

## 2 3 5 2 Upper South Walnut Creek

At the Mound Area, station SW-60 (see Figure 4-2) is located at a corrugated metal pipe discharging South Walnut Creek flow which originates to the west of SW-56 (not sampled in 1989). Stations SW-56 and SW-101 are on a ditch that appears to be seepage from the base of the hill to the south. The ditch is not part of the main flow of South Walnut Creek, as the creek is routed beneath this area by the corrugated metal pipe. Water in the ditch eventually discharges to the South Walnut Creek through a concrete pipe. The flow in South Walnut Creek upstream of Pond B-4 is primarily the combined flow from the discharge of these culverts and a spring or drain discharge (SW-59) located at the base of the hill to the south and downstream of the culverts. This combined flow is sampled at SW-61, which is located at the confluence. (Note: Prior to November 1987, SW-61 was located at the outlet of the concrete pipe mentioned above. The sample data for 7/22/87 and 11/11/87 were obtained from the effluent of the concrete culvert.) Stations SW-21 and SW-23 are located downstream of SW-61. SW-22 is located southeast of the principal drainage and was dry during the reported sampling events. It is noted that a sewage treatment plant is located just downgradient of SW-61 on the north bank of the drainage. The effluent from the plant is piped directly to Pond B-3.

The upper reaches of South Walnut Creek, as characterized by data for stations SW-56, SW-59, SW-60, SW-61, and SW-101, contain  $\text{CCl}_4$ , PCE, and TCE in concentrations in excess of  $200 \mu\text{g/l}$ , with lesser and infrequent concentrations of 1,1-DCE, 1,1-DCA, 1,2-DCE, vinyl chloride (all are possible degradation products of TCE and PCE), acetone, bromo-dichloromethane, and methylene chloride. The latter compounds may be contaminants but the data does not allow this conclusion to be drawn with certainty. These stations also frequently have surface water concentrations above ARARs for TDS and uranium. The TDS and uranium concentrations are typical of the alluvial ground water in the vicinity of the 903 Pad and Mound Areas.  $\text{CCl}_4$ , PCE, TCE, and elevated zinc are also present in the alluvial ground water at the Mound Area.

Stations SW-21 and SW-23, approximately 500 feet farther downstream from SW-61, exhibit low levels of contamination. Although only one datum exists for each station (August 1986 sampling),  $\text{CCl}_4$  ( $9 \mu\text{g/l}$ ) was the only volatile organic detected at SW-21, and volatile organics were absent at the farther downstream station, SW-23. Although there are no August 1986 data for the upstream stations, the data suggest the organics have volatilized over this reach.

#### 2.3.5.3 Seeps at the East Trenches Areas

Of the two seeps at the East Trenches Areas (SW-65 and SW-103), SW-65 has no apparent organic contamination, and SW-103 has the constant presence of  $\text{CCl}_4$  at concentrations less than  $10 \mu\text{g/l}$ . Dissolved uranium was also above ARAR at SW-65. Like the 903 Pad and Mound Areas, the chemistry of these seeps is similar to the localized ground water.

#### 2.3.6 Air Contamination

The 903 Pad Area is recognized as the principal source of airborne plutonium contamination at the RFP. An extensive air monitoring network known as the Radioactive Ambient Air Monitoring Program (RAAMP) is maintained at the Plant in order to monitor particulate emissions from the 903 Pad Area and other Plant facilities. Historically, the particulate samplers located immediately east, southeast, and northeast of the 903 Pad, Mound, and East Trenches Areas have shown the highest plutonium concentrations. This finding is corroborated by the results of soil surveys which indicate elevated plutonium concentrations to the east, particularly southeast of the area. However, RAAMP has found ambient air samples for plutonium to be well within the DOE guidelines of  $20.0 \times 10^{-6} \text{ pCi/l}$  established for the protection of human health (Rockwell International, 1987b).

#### 2.3.7 Summary of Contamination

The Phase I RI investigations of environmental media lead to the general conclusions that volatile organic and radionuclide contamination exists in soils, surface water and ground water around several IHSSs,



and that the distribution and magnitude of the contamination can be better delineated via sampling and analysis planned for the Phase II investigation

TCE, PCE and  $\text{CCl}_4$  are the principal organic contaminants in surface and ground waters, with lesser amounts of their degradation products and other compounds at numerous sampling sites throughout OU 2. Plutonium and americium in surface water samples are other apparent indicators of RFP-derived contamination.

Several metals and other inorganic constituents (including uranium) are also above background in the environmental media, but the data do not permit unambiguous conclusions with regard to contamination. The uncertainty results in part from the absence of clear concentration gradients and from the limited knowledge of the inorganic composition of waste sources in OU 2. Natural processes (e.g., evaporative concentration) may govern the source and distribution of such inorganic constituents. This will be further investigated in the context of long-term remediation at OU 2.

## 2.4 ANALYTICAL DATA

Organic, inorganic and radionuclide contaminants exist in OU 2 surface water. Volume II (Appendix B) presents a compilation of volatile organic, inorganic and radiochemistry data for all surface water stations at OU 2 that are available at this time. Only a small fraction of the data have been validated; they are identified in the appendices by a qualifier adjacent to each datum. The qualifiers "V" (valid), "A" (acceptable with qualifications), and "R" (rejected) are assigned in accordance with the ER Program Quality Assurance/Quality Control (QA/QC) Plan (Rockwell International, 1989c). Rejected data either did not conform to the QA/QC procedures, or insufficient documentation exists to demonstrate conformance with these procedures. These data, at best, can only be considered qualitative measures of the analyte concentrations. The schedule for the IM/IRA does not permit waiting for all data to be validated. However, the validated data and their similarity to unvalidated data are considered sufficient to justify and to define the general configuration of the IM/IRA.

## 2.5 SITE CONDITIONS THAT JUSTIFY AN IRA

There is not an immediate threat to the public health and environment posed by contaminants in surface water at OU 2. However, locally high concentrations of VOCs, and the presence of radionuclides above ARAR in seeps and the upper reach of South Walnut Creek, represent sources for continuing contaminant downstream migration. Although the water is ultimately retained in downstream retention ponds, tested, and treated to meet the discharge requirements of the NPDES permit before release, implementation of this IM/IRA will further insure prevention of uncontrolled releases of contaminated water. Such an action will be consistent with the goals for a final remedy at the site. This IM/IRA will focus only on controlling the migration of hazardous substances in surface water originating from these areas, and does not address soil or ground-water contamination at OU 2. A Phase II Remedial Investigation Plan has been prepared to further characterize the extent of contamination in preparation for further remedial actions at OU 2.

## SECTION 3

### IDENTIFICATION OF INTERIM REMEDIAL ACTION OBJECTIVES

#### 3 1 SCOPE OF INTERIM MEASURES/INTERIM REMEDIAL ACTION

The overall objective of the IM/IRA at OU 2 is the mitigation of downgradient contaminant migration within surface water and the treatment of collected surface water to achieve, to the extent practicable, ARARs (see Section 3 3) ARARs define the remediation goals for the interim action Based on the meetings between DOE, CDH, and EPA during February and March 1990, DOE is proposing specific point source locations for the collection of contaminated surface water, and that this interim action provide for the collection and treatment of flows exclusive of those resulting from high precipitation events

#### 3 2 INTERIM REMEDIAL ACTION SCHEDULE

Revisions to this plan based on public comment, preparation of a Responsiveness Summary pursuant to the public meeting, treatability studies, and design and implementation of this IM/IRA will occur through the spring of 1991 Milestones for specific activities are presented in Table D-1, Appendix D The milestone schedule shown in Table D-1 is the current schedule as proposed in the FFACO/IAG (DOE 1990a)

#### 3 3 COMPLIANCE WITH POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) AND PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The NCP [FR Vol 55, No 46, 8848, 40 CFR 300 430 (e)] requires that, in development of alternatives for final remediation, the following be considered

- 1 ARARs
- 2 for systemic contaminants, concentration levels that will not cause adverse effects to the human population and sensitive subgroups over a lifetime of exposure,
- 3 for carcinogens, concentration levels that represent an excess lifetime individual cancer risk less than  $10^{-4}$  considering multiple contaminants and multiple pathways of exposure,
- 4 factors related to detection limits,
- 5 for current or potential sources of drinking water, attainment of Maximum Contaminant Level Goals (MCLGs) or Maximum Contaminant Levels (MCLs), if MCLGs are zero, and,
- 6 attainment of Clean Water Act (CWA) water quality criteria where relevant and appropriate

The IAG, in paragraph 150, states "Interim Remedial Actions/Interim Measures shall, to the greatest extent practicable attain ARARs " Also for interim actions, the NCP [40 CFR 300 430(f)] specifically notes that an ARAR can be waived if the action is to become part of the final remedy that will attain ARARs The results of the treatability studies identified in Section 6 4 will allow evaluation of the extent to which the IM/IRA will attain ARARs, i e , it may not be practicable to attain all ARARs for this interim action and ARAR waivers or alternate concentration limits may be requested after the study is completed

This section identifies and analyzes ARARs relevant to the IM/IRA at OU 2 and discusses how the action will be protective of human health and the environment This remedial action is considered an on-site IM/IRA to be administered under CERCLA, therefore, only substantive and not administrative requirements apply Permits, for example, are not required (per paragraph 121 of the IAG)

"Applicable standards" may be defined as substantive environmental protection requirements, criteria, or limitations, promulgated under federal or state law, that specifically address a hazardous substance, pollutant, contaminant, response action, location, or other circumstances at a Superfund site "Relevant and appropriate requirements' are those substantive environmental protection requirements, promulgated under federal or state law, that, while not jurisdictionally applicable to a hazardous substance, pollutant, contaminant, remedial action location or other circumstance at the site, address problems sufficiently similar to those encountered at the site that their use is well suited to the particular site ARARs must be identified on a site-specific case-by-case basis

In general, there are three categories of ARARs These categories are

- Ambient or chemical-specific requirements
- Locational requirements
- Performance, design, or other action-specific requirements

Each category is discussed in more detail below

### 3 3 1 Ambient or Chemical-Specific Requirements

Ambient or chemical-specific requirements set health- or risk-based concentration limits in various environmental media for specific hazardous substances or pollutants. These requirements set protective clean-up levels for the chemicals of concern in the designated media, or indicate a safe level of air emission or wastewater discharge.

ARARs are derived primarily from Federal and state health and environmental statutes and regulations. The following may be considered when establishing clean-up standards, but are not considered ARARs: Health Effects Assessments, Health Advisories, Chemical Advisories, and Guidance Document criteria. These and any proposed standards are classified as items to be considered, or TBCs. Where background concentrations for constituents are above the ARAR for that constituent, a waiver from the ARAR may be appropriate. A summary of ARARs for the contaminants found in surface water at OU 2 are presented in Appendix E, Tables E-1 1 through E-1 4. Tables E-1 1, E-1 2, E-1 3, and E-1 4 present ARARs for volatile organics, metals, conventional pollutants, and radionuclides, respectively.

When more than one ARAR has been identified for a contaminant, the most stringent standard has been identified as the ARAR. An ARAR analysis for volatile organics, metals, conventional pollutants, and radionuclides, respectively, is presented in Tables E-2 1, E-2 2, E-2 3, and E-2 4. The screening process includes consideration of both ground-water and surface water standards because of the probable interaction of alluvial ground water and surface water in the drainages of the RFP. Of the elements/compounds detected in surface water at OU 2, there are no ARARs for calcium, magnesium, potassium, sodium, bicarbonate, and strontium. However, the TDS ARAR establishes the acceptable aggregate concentration for the above major ions (excluding strontium). Until an acceptable risk-based concentration is established for strontium, its background concentration is TBC.

### 3 3 1 1 Safe Drinking Water Act Maximum Contaminant Levels (MCLs) and MCL Goals

Because surface water at OU 2 is a source of drinking water, MCLs are potentially relevant and appropriate for all phases of the IM/IRA. MCLs are derived from the Safe Drinking Water Act (SDWA) (PL 93-523). They represent the maximum permissible level of a contaminant in water which is delivered to the free-flowing outlet of the ultimate user of a public water system [40 CFR 141.2(C)]. Per the new NCP, MCLGs have also been considered in developing clean-up standards.

### 3 3 1 2 Ambient Water Quality Criteria

The Ambient Water Quality Criteria (AWQC) are non-enforceable guidance developed under the CWA. Guidance is set for surface waters for the protection of aquatic life and for the protection of human health, based on consumption of both drinking water and aquatic organisms from that water. The proposed IM/IRA involves treatment and discharge to a surface water that has a use-protected designation, aquatic life Class II warm water. Per the new NCP, the AWQC are considered potentially relevant and appropriate under this circumstance.

### 3 3 1 3 Colorado Surface and Ground-Water Quality Standards

The CDH has adopted interim ground-water quality standards for many organic compounds. These are considered potentially applicable for the constituents where they exist. Some of the standards are lower than the current standard detection limits for the compounds of concern. When this occurs, the detection limit will be considered as the ARAR.

The CDH has also promulgated ground-water quality standards for many inorganic compounds for both human health and agricultural uses. These standards are considered to be potentially applicable since future or downgradient use of the aquifer is not restricted. Where standards exist for both human health and agricultural uses, the more stringent standard is considered to be the ARAR.

Permanent surface water quality standards have been adopted by CDH for Walnut Creek and Woman Creek. These include standards for many organic, inorganic and radionuclide parameters. These standards went into effect March 30, 1990, and are considered potentially applicable.

#### 3.3.1.4 RCRA Ground-Water Protection Standards

Owners or operators of facilities that treat, store, or dispose of hazardous waste must ensure that hazardous constituents listed in 6 CCR (Colorado Code of Regulations) 1007-3 and 40 CFR 264, Appendix VIII entering the ground water from a regulated unit do not exceed concentration limits under 6 CCR 1007-3 and 40 CFR 264.94. The concentration limits include standards for 14 compounds, with background or alternate concentration limits (ACLs), used as the standard for the other RCRA Appendix VIII constituents. These concentration limits apply to RCRA-regulated units subject to permitting (landfills, surface impoundments, waste piles, and land treatment units) that received RCRA hazardous waste after July 26, 1982. Although this area does not contain RCRA-regulated units, it does contain IHSSs. Therefore, these RCRA (Subpart F) regulations are considered relevant and appropriate. However, because ACLs based on protection of public health have not been established for the Appendix VIII constituents, the RCRA clean-up criteria of background concentrations are viewed as TBC. Background concentrations for 40 CFR 264, Appendix IX constituents not listed in Appendix VIII are also TBC.

#### 3.3.1.5 Protection of Human Health and the Environment

As illustrated by the hazard quotients and carcinogenic risks listed in Tables E-1.1 through E-1.4, achieving the ARARs should result in a clean-up action that is protective of human health and the environment. The hazard quotients ( $< 1$ ) indicate no impacts from systemic contaminants. With respect to carcinogens, the calculated incremental cancer risks exceed  $10^{-4}$  for some of the organic carcinogens as well as for arsenic and beryllium. However, the cancer risks are computed on the basis of the detection limit and therefore can only be considered a possible maximum carcinogenic risk, the actual risk is unknown but likely to be considerably lower. Removing these contaminants to non-detectable levels and attaining, to the extent practicable, the other ARARs, the IM/IRA is considered protective of human health and the environment.

### 3 3 2 Locational Requirements

Locational requirements are statutes or regulations which set restrictions on activities or limits on contaminant levels solely because of location, e g , within a floodplain, wetland, historic place, or sensitive ecosystem or habitat. Examples of locational requirements applicable to the surface water IM/IRA are federal and state siting laws for hazardous waste facilities (floodplain restrictions), and federal regulations to avoid adverse effects to wetlands (40 CFR Part 230, 33 CFR Parts 320-330, and 40 CFR Part 6, Appendix A). Also included are the floodplain regulations promulgated pursuant to the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program, and the CDH Water Quality Division's regulations pertaining to pre-approval of a treatment facility location because the action includes discharge of treated water to surface waters of the state.

### 3 3 3 Performance, Design, or Other Action-Specific Requirements

Performance, design, or other action-specific requirements set controls or restrictions on particular kinds of activities related to management of hazardous substances or pollutants. These requirements are not triggered by the specific chemicals present at a site, but rather by the particular IM/IRA alternatives that are evaluated as part of this plan. Action-specific ARARs are technology-based performance standards, such as the Best Available Technology (BAT) standard of the Federal Water Pollution Control Act. Other examples include RCRA treatment, storage, and disposal standards, and Clean Water Act pretreatment standards for discharges to publicly-owned treatment works (POTWs). RCRA LDRs for certain organic contaminants [40 CFR Part 268.40] are also action-specific ARARs for the discharge of treated water to either a surface or groundwater body. Action-specific ARARs for the interim remedial actions evaluated here are included in Table E-3.



## SECTION 4

### IDENTIFICATION AND ANALYSIS OF IM/IRA ALTERNATIVES

#### 4.1 SURFACE WATER COLLECTION AND TREATMENT ALTERNATIVES

This section presents the technique for collection of contaminated surface water and a detailed evaluation of alternative treatment technologies. Treatment technologies corresponding to the following categories are evaluated in this section:

- Treatment for Suspended Solids Removal,
- Treatment for Radionuclide Removal, and
- Treatment for Organic Constituent Removal

The treatment technologies selected for consideration are based on their probability of attaining the effluent requirements (ARARs presented in Section 4.1.2). The process for critical evaluation of the treatment technologies is presented in Section 4.2. The evaluation criteria include effectiveness, implementability and costs of the technology. Section 4.3 examines in detail the technique of surface water collection by diversion at the sources. The treatment technologies are presented and evaluated in Section 4.4. The treatment system designs presented in Section 4.4 are conceptual, with only enough detail to determine relative costs. Detailed design and costing for the IM/IRA will be conducted after the results of the bench and field-scale treatability studies are obtained. The comparative cost evaluations employ a standard 30-year basis for present worth analysis. However, because the IM/IRA could become a part of the long-term remedial action, the actual service life of the OU 2 surface water IM/IRA is not known at this time. Lastly, all solid waste generated during the IM/IRA, with the exception of activated carbon (e.g., filter cake, excavated soils from installation of the collection system and sediments accumulating in the collection system during operation) will be characterized and handled according to the RFP waste management operating procedures. For costing purposes, however, it is assumed that these wastes will be disposed of as low-level mixed waste.

#### 4 1 1 Surface Water Collection Technologies

As mentioned in Section 1 0, general agreement between EPA, CDH and DOE was reached on the specific locations for collection of contaminated surface water. The seeps and in-stream surface water stations exhibiting organic and radionuclide contamination were agreed upon as collection points, either at the specific stations or immediately downstream at a point of confluence. Figures 4-1 and 4-2 show the seeps and in-stream surface water monitoring stations exhibiting organic and radionuclide contamination. Figure 4-2 offers a detailed plan view of the locations of SW-59, SW-60, and SW-61 in the South Walnut Creek drainage. Agreed-upon OU 2 seeps and in-stream stations include those associated with the 903 Pad and Lip Site Area (SW-50 SW-51, SW-52, SW-55, SW-57 SW-58 and SW-77), SW-53, SW-63, SW-64, contaminated surface water stations along Upper South Walnut Creek (SW-56, SW-59, SW-60, SW-61, and SW-101) and SW-103. Seepage originating from the 903 Pad and Lip Site Area collects at either SW-55 or SW-77. Seepage at stations SW-53, SW-63, and SW-64 are downstream and separate from the 903 Pad and Lip Area sources. Seepage in this area generally flows toward the South Interceptor Ditch and ultimately collects in Pond C-2. Similarly, contaminated water in the upper reach of South Walnut Creek eventually flows past SW-61 and ultimately enters Pond B-5 via Pond B-4. Most of the identified seeps flow only seasonally.

At the meetings in February and March 1990 between DOE and the regulatory agencies, seep SW-103 was also targeted for collection. It is located within the South Walnut Creek Drainage upstream of Pond B-5 (Figure 4-1). The seep contains trace concentrations of  $\text{CCl}_4$  ( $< 10 \text{ ug/l}$ ) and concentrations of total plutonium, americium, uranium, and several metals above ARARs. However, at the time, the physiographic features of the seep were not discussed. Of particular note is the large area of seepage (approximately 30,000 sq ft) and the location of the seep on a steep hillside. These features necessitate an elaborate drainage system for seepage collection and, more importantly, render access by construction equipment extremely difficult. The elaborate drainage system required to collect the flow from SW-103 would have adverse effects on the large area of wetland present at this seep, and disturbance of saturated soils may release significant quantities of contaminants downstream during construction. For these reasons, and because the  $\text{CCl}_4$  and dissolved inorganic constituent concentrations are low, and the contribution of radionuclide and metals contamination from SW-103 to the South Walnut Creek drainage above the retention ponds is likely to be

insignificant relative to that resulting from contaminated surface water runoff, collection of water at this seep is no longer recommended for this IM/IRA. In effect, notwithstanding the difficulty and potentially dangerous working conditions of constructing a surface water collection system at SW-103, it would appear that the environmental impacts of such a construction would outweigh the benefits of surface water collection and treatment at this location.

Several alternatives exist for collecting the contaminated OU 2 surface waters mentioned above. First and foremost is collection of surface water by diversion at the source. This technique employs existing or newly constructed diversion structures at the seep or in-stream stations to divert the surface water into collection sumps. This method of surface water collection was agreed to by EPA, CDH, and DOE in the February and March 1990 meetings. This technique will be further discussed and evaluated in Section 4.3. For comparative purposes, two other surface water collection methods are discussed below.

A second method of surface water collection is by ground-water withdrawal using an upgradient well array or french drain. This technique lowers the ground-water table and eliminates seepage, allowing separation of contaminated ground water (seepage) from surface water runoff. However, the hydrogeology at OU 2 is not adequately understood to design an effective ground-water withdrawal system. For example, it is not known whether the seepage is due to water originating in the Rocky Flats Alluvium and being released to the surface through colluvium because of slope changes and/or bedrock highs, or whether the source of the water is bedrock sandstone subcropping in this vicinity. This information is critical to the design of an effective ground water withdrawal system. EPA alluded to the issue in their transmittal letter (January 9, 1990) which accompanied their comments on the draft OU 2 ground-water IRAP, wherein they stated "this OU is difficult to address on an interim basis due to the lack of comprehensive quality data characterizing the nature and extent of contamination. It is uncertain whether the most probable imminent threat, the alluvial ground-water system, can be effectively addressed at this time." For this reason, collection of surface water by ground-water withdrawal is eliminated as a reasonable alternative for the IM/IRA and will not be considered for further detailed evaluation.

A third collection alternative is to allow the contaminated OU 2 surface water to continue to flow through the South Walnut Creek and Woman Creek drainages into retention Ponds B-5 and C-2, respectively. The

contaminated OU 2 surface waters, along with all other waters collected and retained in the ponds, would be transferred from the ponds for treatment. This method has three primary drawbacks. First, there is a potential threat of transferring the surface water contaminants to ground waters within the South Walnut Creek and Woman Creek drainage basins via infiltration. Secondly, release of volatile organic compounds to the atmosphere will occur while the surface water is in transit to the retention ponds. Finally, allowing the OU 2 surface waters to mix with other waters retained in the ponds generally increases the volume of dilute contaminated water at the RFP facility that may require treatment. For these reasons, collection of OU 2 surface waters at retention Ponds B-5 and C-2 is eliminated as a reasonable alternative for the IM/IRA and will not be considered for further detailed evaluation.

#### 4.1.2 Surface Water Treatment Technologies

Based on the objectives of the surface water IM/IRA discussed in Section 3.1, Table 4-1 has been prepared to establish the basis for conceptual design for surface water treatment. The influent constituent concentrations listed in Table 4-1 are estimated from a flow-weighted maximum concentration model representing a worst case scenario. The influent concentrations are computed by flow weighting the maximum constituent concentrations observed at each monitoring station or group of monitoring stations considered in this project: 903 Pad and Lip Area seeps (SW-50, SW-51, SW-52, SW-55, SW-57, SW-58, and SW-77), SW-53, Upper South Walnut Creek in-stream monitoring stations (SW-56, SW-60, SW-61, and SW-101), SW-59, SW-63 and SW-64. The flow values used to weight the maximum concentrations in the calculation are the corresponding collection system design flows (established in Section 4.3 and listed in Table 4-4). A spreadsheet illustrating computation of the flow-weighted maximum concentration computation is shown in Table E-1, Appendix E.

Table E-1 shows that strict application of this worst case scenario model predicts vinyl chloride, methylene chloride and acetone influent concentrations above their respective ARAR values. However, examination of the surface water data presented in Appendix B reveals that these constituents are not likely to be present in the influent at levels above ARAR. Vinyl chloride, methylene chloride and acetone were detected at levels above ARAR only at Upper South Walnut Creek stations SW-56, SW-60 and SW-101. However, as proposed in Section 4-3, contaminated surface water in Upper South Walnut

**TABLE 4-1**  
**BASIS FOR DESIGN OF SURFACE WATER TREATMENT PLANT**

	<u>Units</u>	<u>Influent Concentration<sup>a</sup></u>	<u>Effluent Requirements<sup>b</sup></u>
<u>Organics</u>			
Carbon Disulfide	µg/l	5	5U
1,1-Dichloroethene	µg/l	127	5U
1,1-Dichloroethane	µg/l	6	5U
1,2-Dichloroethene (total)	µg/l	10	5U
Carbon Tetrachloride	µg/l	249	5U
Trichloroethene	µg/l	298	5U
Tetrachloroethene	µg/l	235	5U
<u>Dissolved Metals</u>			
Antimony	mg/l	0 0607	0 060
Beryllium	mg/l	0 0052	0 005U
Iron	mg/l	0 3476	0 300
Manganese	mg/l	0 6073	0 050
Selenium	mg/l	0 0063	0 010
Strontium	mg/l	0 8772	0 396
Tin	mg/l	0 7641	0 100
<u>Total Metals</u>			
Aluminum (Al)	mg/l	24 0745	5 000
Antimony (Sb)	mg/l	0 645	0 060
Barium (Ba)	mg/l	1 5985	1 000
Beryllium (Be)	mg/l	0 0439	0 005U
Cadmium (Cd)	mg/l	0 0120	0 010
Chromium (Cr)	mg/l	0 1642	0 050
Cobalt (Co)	mg/l	0 1105	0 050
Copper (Cu)	mg/l	0 2281	0 025U
Iron (Fe)	mg/l	155 5478	1 000
Lead (Pb)	mg/l	0 1664	0 005U
Lithium (Li)	mg/l	0 5859	2 500
Manganese (Mn)	mg/l	2 8410	1 000
Mercury (Hg)	mg/l	0 0019	0 0002U
Molybdenum (Mo)	mg/l	0 1426	0 100
Nickel (Ni)	mg/l	0 1922	0 320
Selenium (Se)	mg/l	0 0078	0 010
Strontium (Sr)	mg/l	0 9081	0 382
Tin (Sn)	mg/l	0 1941	0 100
Vanadium (V)	mg/l	0 4244	0 024
Zinc (Zn)	mg/l	1 3159	0 050

TABLE 4-1 (cont )

## BASIS FOR DESIGN OF SURFACE WATER TREATMENT PLANT

	<u>Units</u>	<u>Influent Concentration<sup>a</sup></u>	<u>Effluent Requirements<sup>b</sup></u>
<u>Dissolved Radionuclides</u>			
Gross Alpha	pCi/l	17 70	11
Gross Beta	pCi/l	33 86	19
Plutonium 239,240	pCi/l	0 17	0 05
Total Uranium	pCi/l	10 17	10
<u>Total Radionuclides</u>			
Gross Alpha	pCi/l	632	11
Gross Beta	pCi/l	463	19
Plutonium 239,240	pCi/l	7 34	0 05
Americium 241	pCi/l	2 96	0 05
Total Uranium	pCi/l	13 21	10

<sup>a</sup> The influent concentrations are based on flow-weighted maximum concentrations of 903 Pad and Lip Area Seeps (SW-50, SW-51, SW-52, SW-55, SW-57, SW-58, and SW-77), SW-53, SW-59, SW-63, SW-64, and Upper South Walnut Creek seeps and surface water stations (SW-56, SW-60, SW-61, SW-101). The computation is illustrated by the spreadsheet shown in Table F-1, Appendix F. The maximum observed concentration for each station or group of stations is multiplied by the corresponding collection station design flow. The multiplication products for each collection station are summed and divided by the total design flow (51.5 gpm). Concentration data used in the flow-weighted maximum concentration computation is obtained from the 1987, 1988, 1989, and 1990 field investigations.

<sup>b</sup> Based on Applicable or Relevant and Appropriate Requirements (ARARs). The "U" designation following many of the effluent concentrations indicates that the concentration is the detection limit for that constituent.

Creek will be collected at the downstream station SW-61 where vinyl chloride, methylene chloride and acetone have always been estimated below detection limits and/or were also present in the associated laboratory blanks. These compounds are, therefore, not included in the basis for design of the surface water treatment plant. The effluent concentrations listed in Table 4-1 correspond to the ARAR for each constituent. Treatment technologies for radionuclides and metals removal that are considered in this IM/IRA Plan include chemical precipitation, cross-flow membrane filtration, and ion exchange. Liquid-phase Granular Activated Carbon (GAC) adsorption, air stripping with liquid and vapor phase GAC adsorption, and ultraviolet (UV)/peroxide oxidation are considered for volatile organic compound (VOC) removal. Many treatment units suitable for removal of VOCs and radionuclides from water require that suspended solids be removed from the influent to prevent performance degradation and/or fouling. Removal of suspended solids down to the 1  $\mu$ m particle size range ensures optimum treatment system performance. The two candidate influent pretreatment alternatives for removal of suspended solids considered for this IM/IRA are cross-flow membrane filtration and polymer addition with granular media filtration in a continuous backwash filter. Pretreatment is also a vehicle for removal of particulate radionuclides and metals and, with chemical addition, should facilitate precipitation and adsorption of soluble radionuclides and metals.

## 4.2 IM/IRA ALTERNATIVE EVALUATION PROCESS

The following discussion of the IM/IRA alternative evaluation process is based on EPA guidance for the preparation of an EE/CA.

### 4.2.1 Effectiveness

The criteria for effectiveness evaluation of remedial alternatives includes protection and the use of alternatives to land disposal. Protection includes protection of the community and workers during the remedial action, threat reduction, length of time until protection is achieved, compliance with criteria, advisories and guidance, risk of potential exposure to residuals remaining on site, and continued reliability over the life of the IM/IRA. The effectiveness criteria also includes use of alternatives to land disposal, thus promoting treatment or recycling. In addition to this EE/CA guidance, the alternatives will be evaluated with respect to reduction of toxicity, mobility, and volume of wastes per the March 1990 NCP.

#### 4 2 2 Implementability

The criteria for implementability evaluation of remedial alternatives includes technical feasibility, availability, and administrative feasibility. Technical feasibility includes the ability to construct the technology, maintain its operation, meet process efficiencies or performance goals, demonstrated performance, evaluate impact of environmental conditions, and comply with the SARA requirement that removal actions should contribute to the efficient performance of long-term remedial action to the extent practicable. Availability includes the availability of necessary equipment, materials and personnel, availability of adequate off-site treatment, storage, and disposal capacity, if appropriate, and description of post-remedial site controls which will be required at the completion of the action. Administrative feasibility includes the likelihood of public acceptance of the alternative including site and local concern, coordination of activities with other agencies and ability to obtain any necessary approvals or permits.

#### 4 2 3 Costs

The criteria for evaluation of remedial alternative cost includes total cost and statutory limits. Total cost includes direct capital costs, indirect capital costs, and operating and maintenance costs. Since the surface water IM/IRA at OU 2 is not an EPA-financed remedial action, the \$2 million statutory cost limit does not apply.

#### 4 3 EVALUATION OF THE IM/IRA SURFACE WATER COLLECTION SYSTEM

As discussed earlier, OU 2 contaminated surface waters will be collected by diversion at the sources. This section further describes this technique as it applies to the surface water seeps and in-stream stations considered in this IM/IRA. This presentation includes a discussion of the anticipated seep and in-stream station flows and an evaluation of the collection technique per the evaluation process outlined in Section 4 2.



#### 4 3 1 Surface Water Collection by Diversion at the Sources

##### 4 3 1 1 Description

Figure 4-3 shows the locations of the surface water diversion and collection systems proposed for the IM/IRA. The collection systems (CS) are denoted CS-53, CS-55, CS-59, CS-61, CS-63, and CS-64. The proposed location of the surface water treatment plant is also indicated on Figure 4-2. Because of anticipated flow considerations discussed below, transport of the water from the collection systems to the treatment plant is by tank truck for CS-53, CS-55, CS-63 and CS-64, and by pipeline for CS-59 and CS-61. (Although tank truck transport is proposed at this time, pre-design analysis may indicate pipeline transfer to be the most effective water conveyance for the actual system implemented.) Figure 4-3 indicates method of water transfer to the treatment system only. The proposed transportation routes for transfer of water from CS-53, CS-55, CS-63 and CS-64 are discussed in Section 4 3 1 3.

Design flow rates for surface water collection systems CS-59, CS-61, CS-55, CS-53, CS-63 and CS-64 are based on flows from stations SW-59, SW-61, SW-55 plus SW-77, SW-53, SW-63 and SW-64, respectively. The design flow rates are maximum flows observed in the 1988, 1989, and 1990 field investigations, excluding flows related to high precipitation events. Only design flows will be collected from the OU 2 surface water seeps and in-stream monitoring stations. Historical flow data for SW-59 and SW-61 are listed in Tables 4-2 and 4-3, respectively. Table 4-2 lists only two flow rates of sufficient quantity to be measurable for SW-59 (each 4.5 gallons per minute [gpm]). Rocky Flats personnel have observed flows at SW-59 monthly since the spring of 1990. They report that a flow of approximately 0.5 gpm was occurring at each observation. Table 4-3 indicates two high flow events for SW-61 of 166 gpm. All other data for SW-61 is below 36 gpm. Only one historical flow measurement for station SW-64 is available (4.5 gpm measured on 6/20/89). Flow measurements for stations SW-53, SW-55, SW-63 and SW-77 were not obtained prior to this writing.

To complement the historical data and to obtain wet season flow data not corresponding to a major precipitation event, flow measurements at SW-61 and SW-55 were obtained in April 1990. A cutthroat flume

**TABLE 4-2**  
**SURFACE WATER FLOW DATA FOR SW-59<sup>1</sup>**

<u>Flow (GPM)<sup>2</sup></u>	<u>Date of Flow Measurement</u>
4 5	07/01/88
4 5	03/20/89
0	05/11/89
0	06/08/89
0	07/06/89
0	08/10/89
0	09/18/89
0	10/03/89
0	11/06/89
0	12/06/89

<sup>1</sup> Flow data obtained from the 1988 and 1989 field investigations

<sup>2</sup> A flow rate of zero indicates either no seepage or an imperceptible flow. Rocky Flats personnel observed flows at SW-59 monthly since the spring of 1990. They report that a flow of approximately 0.5 gpm was occurring at each observation.

**TABLE 4-3**  
**SURFACE WATER FLOW DATA FOR SW-61<sup>1</sup>**

<u>Flow (GPM)<sup>2</sup></u>	<u>Date of Flow Measurement</u>
35.9	07/01/88
166	03/20/89
90	05/15/89
90	06/09/89
90	07/06/89
45	08/03/89
180	09/11/89
45	10/03/89
45	11/06/89
0	12/06/89
180	02/09/90
166	03/12/90

<sup>1</sup> Flow data obtained from the 1988, 1989 and 1990 field investigations

<sup>2</sup> A flow rate of zero indicates either no seepage or an imperceptible flow

manufactured by Baski Water Instruments, Inc. was used to measure the flow at SW-61, and a bucket and stopwatch technique was used to measure the flow at SW-55. Flows of 37.3 gpm at SW-61 and 3.0 gpm at SW-55 were recorded. Surface water seep flows at SW-53, SW-63, and SW-77 were imperceptible and quantitative measurements were not obtained.

Based on the historical data available and the April 1990 field measurements and observations, design flow rates and average annual withdrawal rates for each of the collection systems were established. The design and withdrawal flow rates are presented in Table 4-4. A design flow of 0.5 gpm is assigned to those seeps observed to have imperceptible flow rates (SW-53, SW-63 and SW-77). Design flows of 38 gpm and 3.0 gpm were assigned to SW-61 and SW-55, respectively. These flows represent an above-average precipitation wet season flow not corresponding to a major storm event. The historical maximum flows for SW-59 and SW-64, 4.5 gpm in each case, is used as the design basis for these seeps. Average annual withdrawal rates shown in Table 4-4 are estimated as follows. For SW-61, the historical flow data spanning the 12-month period of March 1989 to March 1990 (See Table 4-3) is averaged. In the averaging process 38 gpm, the design withdrawal rate at SW-61, is substituted for 166 gpm for the 3/20/89 and 3/12/90 recorded measurements. This calculation gives an annual average withdrawal rate of approximately 14 gpm. Applying this calculation to all historical data for SW-59 (See Table 4-2), the annual average flow rate is found to be approximately 1 gpm. Since there is limited historical flow data for the seeps within the Woman Creek drainage (i.e. SW-53, SW-55, SW-63, SW-64 and SW-77) are estimated based on the SW-61 flow data. For SW-61, the computed average annual flow rate (14 gpm) is 37 percent of the design flow rate (38 gpm). Applying the 37 percent factor to the Woman Creek seep design flows gives average annual withdrawal rates of 0.2, 1.1, 0.2, 1.7, and 0.2 gpm for SW-53, SW-55, SW-63, SW-64, and SW-77 respectively.

Upper South Walnut Creek flow will be collected at the downstream station SW-61 by a new surface water diversion weir and pump station. The weir will serve to divert up to 38 gpm from the drainage. Contaminated surface water will flow from upstream of the weir to a manhole and sump. For cost estimating purposes, it will be assumed that a 1,000-gallon capacity, precast concrete sump will be used at CS-61. The pumps installed within the manhole will be of the submersible type. The pumping capacity will be designed to accommodate the 38 gpm design flow. If the inflow into the pump station manhole exceeds the pumping rate, however, the excess flow will return through overflow piping to the drainageway below the weir. The

TABLE 4-4

DESIGN FLOWS AND AVERAGE ANNUAL WITHDRAWAL  
RATES FOR SURFACE WATER DIVERSION AND COLLECTION SYSTEM

<u>STATION</u>	<u>DESIGN FLOW (GPM)</u>	<u>AVERAGE ANNUAL WITHDRAWAL RATES (GPM)</u>
SW-53	0 5	0 2
SW-55	3 0	1 1
SW-59	4 5	1 0
SW-61	38	14
SW-63	0 5	0 2
SW-64	4 5	1 7
SW-77	0 5	0 2
	<hr/>	<hr/>
TOTAL	51 5 gpm	18 4 gpm

seep flow from SW-59 will be isolated from the South Walnut Creek drainage and collected separately from CS-61 by diversion into a sump. For cost estimating purposes, it is assumed that a 1,000-gallon capacity, precast concrete sump will be used. Submersible pumps will transfer the collected water to the treatment system. The pumping capacity will be designed to accommodate the 4.5-gpm design flow for CS-59. Although unlikely, if the inflow to the pump station exceeds the pumping capacity, the excess flow will be discharged to South Walnut Creek via an overflow pipe. The overflow will enter South Walnut Creek upgradient of CS-61 and will either be collected by, or allowed to pass, CS-61 depending on whether the creek flow is less than or greater than the 38 gpm design flow for CS-61.

The 903 Pad and Lip Area seeps will be collected by CS-55, a newly installed sump at the outlet of SW-55. This collection scheme makes use of the existing surface water diversion pathways and flows described in Section 2.3.5. Installation of a lined trench connecting SW-77 to SW-55 will allow collection of the flow from SW-77 in CS-55. For cost estimating purposes, it will be assumed that the sump will be a precast concrete structure with a 5000-gallon capacity. To prevent mixing of contaminated 903 Pad and Lip Area seeps with surface water runoff, a surface water diversion berm will be constructed upslope of all seeps using clean fill.

The flow from SW-53 will be collected by a system similar to CS-55. It is assumed that a 5000-gallon capacity concrete sump will be located at the outlet of the existing steel culvert which directs SW-53 flow under the firing range access road. Using clean fill, a surface water runoff diversion berm will be constructed upslope of SW-53.

Surface water seep SW-63 covers a circular area measuring approximately six feet in diameter. A half-circle-shaped trench excavated downslope of the seep will be used to divert seep flow to a sump located at the low point of the trench. For cost estimating purposes, it will be assumed that a precast concrete sump with a capacity of 5000 gallons will be used. The trench will be lined to prevent any recharge to the ground-water system. A surface water runoff diversion berm will be constructed upslope of SW-63 using clean fill.

Surface water seep SW-64 flows into a ditch adjacent to the north side of the site access road shown on Figure 4-1. The seep extends approximately 160 feet within the ditch, and a high point in the center of the

ditch results in water collection on either side of the ditch. A steel culvert buried beneath the access road at the western side of the seep drains the seep water accumulating on this side of the ditch downgradient toward the South Interceptor Ditch. For cost estimating purposes, it will be assumed that a 5000-gallon concrete sump will be located at the outlet of the existing culvert to collect and store this flow. Likewise, a second 5000-gallon concrete sump will be used to collect the seep water flowing east from the high point in the ditch. A surface water runoff diversion berm will be constructed upslope of the existing ditch using clean fill.

All sumps and pipes will be provided with secondary containment to meet RCRA tank regulations. Pipelines will be heat traced to prevent freezing in the winter.

#### 4.3.1.2 Effectiveness

Collection of OU 2 surface water by diversion at the sources is an effective method that satisfies the objectives of the IM/IRA discussed in Section 3.1. Minimization of potential threats to human health and the environment is achieved by diverting, collecting, and treating contaminated surface waters at or near the source. Downstream contaminant migration via surface water and ground water and release of VOCs to the atmosphere is minimized with this surface water collection system. The implementation of this collection action should not adversely affect the safety of nearby communities, and the risk to the environment should not be increased.

Most of the surface water is collected and transferred to the treatment system with little opportunity for worker contact (i.e., CS-59 and 61). As a result, worker exposure to potentially contaminated surface water is minimized. Where worker exposure to surface water occurs (i.e., tank truck transfers and sediment removal), pump and suction equipment minimize contact time, and standard personal protective equipment will offer a high degree of protection.

Residuals (i.e., collected sediments) will not remain onsite; they will be treated or disposed according to the standard RFP waste management procedures. The collection structures are simple in design, and with little periodic preventive maintenance, should offer continued reliability over the life of the IM/IRA.

#### 4.3.1.3 Implementability

The equipment and materials required to construct the surface water diversion and collection systems are standard and readily available. The systems are standard in design and do not require special skills for installation. Sump installation results in disturbance of potentially contaminated soils and potential impact to the environment by release of contaminated dust to the atmosphere and increased release of construction via surface water runoff. This impact will be minimized by implementing the site specific health and safety procedures during construction (i.e., dust suppression, windspeed monitoring/construction shutdown, etc.). These health and safety measures are discussed in Section 7. The effectiveness of surface water collection by diversion, along with implementation of dust suppression procedures during installation should result in a high degree of public acceptance of this technique. Access roads exist to all proposed collection system site locations. Power currently exists near the proposed location for CS-59 and CS-61, the two systems expected to incorporate pumped transfer of the collected water to the treatment facility. Since the collection systems are simple in design they should offer reliable and relatively maintenance-free operation over the life of the IM/IRA. Manholes and sumps will require periodic cleaning to remove accumulated solids.

As mentioned earlier, surface waters collected by CS-53, CS-55, CS-63 and CS-64 are proposed to be transported to the treatment system by tank truck. The anticipated transportation route is from the collection systems to Indiana Street via the site access roads north on Indiana Street to the RFP East Gate entrance and west on Central Avenue to the proposed location of the surface water treatment system. The one-way distance from CS-55 to the treatment facility along the route described above is approximately 5 miles. Based on the 5,000-gallon storage capacities at CS-53, CS-55, and CS-63 and a 10,000-gallon storage capacity at CS-64, and the corresponding collection system design flow rates (see Table 4-4), the minimum time period between tank truck transfers is approximately 1 day, 7 days, 7 days and 15 days, respectively. These estimates are based on a 5,000-gallon capacity tank truck and flows to the collection systems equal to their respective design flows. Based on the minimum time periods between tank truck transfers cited above, the tank truck will make 14 round trips per week between the collection stations and the treatment facility. At 10 miles per round trip, the maximum distance traveled by the tank truck is estimated at 140 miles per week. However, considering that flows will infrequently be at design rates, the average mileage is estimated at approximately 50 miles per week. It is noted that winter conditions may hamper trucking, however, during the winter seep flows are expected to be nominal or non-existent.



#### 4 3 1 4 Costs

Assumed capital and operating costs for the surface water diversion alternative are shown in Table 4-5. The collection system can be constructed for \$481,200, with annual operation and maintenance costs of \$85,200. At an interest rate of 10 percent and an operating life of 30 years, the present worth of this system is approximately \$1,284,380.

### 4 4 EVALUATION OF SURFACE WATER TREATMENT TECHNOLOGIES

#### 4 4 1 Suspended Solids Removal

In this section, cross-flow membrane filtration and granular media filtration using a polymer and continuous backwash filter are evaluated to determine the cost-effective technology for suspended solids removal. These two processes differ from conventional water clarification (chemical addition followed by gravity separation and filtration) by virtue of the lower sludge volumes generated. As discussed in the following subsections, each of these technologies will also remove radionuclides and metals to a certain degree.

##### 4 4 1 1 Cross-Flow Membrane Filtration

#### Description

Cross-flow membrane filtration is a membrane separation technology for removal of suspended solids, dissolved metals, and radionuclides. (Chemical addition and removal mechanisms for dissolved metals and radionuclides are discussed in Section 4 4 2 1.) As shown in Figure 4-4, the process consists of chemical addition, filtration through a 0.1  $\mu\text{m}$  filter, solids recirculation, solids separation and dewatering, and final neutralization. As discussed in more detail in Section 4 4 2 1, chemical addition is a pretreatment step for initiating precipitation, co-precipitation, and adsorption of metals, i.e., conversion to the solid phase. However, the solids will aid in the removal of influent suspended solids by coagulation of fine particles and/or

**TABLE 4-5  
ASSUMED COSTS FOR SURFACE WATER DIVERSION  
AND COLLECTION SYSTEMS**

A	<u>EQUIPMENT AND MATERIALS</u>		<u>CAPITAL COST</u> <u>(DOLLARS)</u>	<u>ANNUAL COST</u> <u>(DOLLARS)</u>
	<u>Quantity</u>	<u>Item</u>		
	5	5000-gallon precast concrete sump	\$50,000	
	1	1000-gallon precast concrete sump	2,000	
	1	500-gallon precast concrete sump	1,000	
	4	Liquid transfer pump	2,000	
	400 l f	Insulated heat traced piping	1,400	
	200 cu yd	Concrete	25,000	
	2	Pump station intake structures	2,000	
	1	5000-gallon tank truck	70,000	
B	<u>INSTALLATION</u>			
	<u>Quantity</u>	<u>Item</u>		
	3	<sup>1</sup> Trench construction	\$ 5,000	
	2	<sup>2</sup> Diversion weir or pump station	24,500	
	6	<sup>3</sup> Sump installation	28,400	
	1 lot	<sup>4</sup> Surface water diversion berms	8,200	
	1 lot	<sup>5</sup> Contaminated soil disposal	101,300	

<sup>1</sup> Trench construction costs are based on 50 manhours of labor at \$60/hr, plus a \$2,000 backhoe rental charge. Trenches include those for surface water collection at CS 55, CS-63 and CS-64.

<sup>2</sup> Diversion weir/pump stations CS 59 and CS 61 installation costs are based on 325 manhours of labor at \$60/hr, plus a \$5,000 backhoe rental charge.

<sup>3</sup> Sump installation costs are based on 390 manhours of labor at \$60/hr, plus a \$5,000 backhoe rental charge.

<sup>4</sup> Surface water diversion berm costs are based on 180 cubic yards of fill at \$11 per cubic yard, and 70 manhours of labor at \$60 per hour, plus a \$2,000 heavy equipment rental charge. The cross sections of the berms are assumed to be trapezoidal [1 foot high X 2 feet wide (top) X 3 feet wide (bottom)]. Estimated upslope berm lengths for CS-53, CS-55, CS 59/CS-61, CS-63 and CS-64 are 600 feet, 900 feet, 100 feet (two 50 foot berms), 50 feet and 300 feet, respectively.

<sup>5</sup> To be conservative, it is estimated that soils excavated for collection system sump and trench installation will be disposed of as hazardous mixed waste (\$450 per cubic yard transportation and disposal cost at the Nevada Test Site). The estimated volume of excavated soils is approximately 225 cubic yards, and corresponds to the following: 40 cubic yards for CS-53 (sump), 43 cubic yards for CS-55 (sump and trench), 3 cubic yards for CS-59 (sump), 10 cubic yards for CS-61 (sump and weir), 42 cubic yards for CS-63 (sump and trench), and 87 cubic yards for CS-64 (2 sumps and trench expansion).

**TABLE 4-5  
ASSUMED COSTS FOR SURFACE WATER DIVERSION  
AND COLLECTION SYSTEMS**

A	<u>EQUIPMENT AND MATERIALS</u>		<u>CAPITAL COST</u> <u>(DOLLARS)</u>	<u>ANNUAL COST</u> <u>(DOLLARS)</u>
	<u>Quantity</u>	<u>Item</u>		
	5	5000-gallon precast concrete sump	\$50,000	
	1	1000-gallon precast concrete sump	2 000	
	1	500-gallon precast concrete sump	1 000	
	4	Liquid transfer pump	2,000	
	400 l f	Insulated heat traced piping	1 400	
	200 cu yd	Concrete	25,000	
	2	Pump station intake structures	2,000	
	1	5000-gallon tank truck	70,000	
B	<u>INSTALLATION</u>			
	<u>Quantity</u>	<u>Item</u>		
	3	<sup>1</sup> Trench construction	\$ 5,000	
	2	<sup>2</sup> Diversion weir or pump station	24,500	
	6	<sup>3</sup> Sump installation	28,400	
	1 lot	<sup>4</sup> Surface water diversion berms	8,200	
	1 lot	<sup>5</sup> Contaminated soil disposal	101,300	

<sup>1</sup> Trench construction costs are based on 50 manhours of labor at \$60/hr, plus a \$2,000 backhoe rental charge. Trenches include those for surface water collection at CS-55, CS-63 and CS-64.

<sup>2</sup> Diversion weir/pump stations CS 59 and CS 61 installation costs are based on 325 manhours of labor at \$60/hr, plus a \$5 000 backhoe rental charge.

<sup>3</sup> Sump installation costs are based on 390 manhours of labor at \$60/hr, plus a \$5 000 backhoe rental charge.

<sup>4</sup> Surface water diversion berm costs are based on 180 cubic yards of fill at \$11 per cubic yard, and 70 manhours of labor at \$60 per hour, plus a \$2 000 heavy equipment rental charge. The cross sections of the berms are assumed to be trapezoidal [1 foot high X 2 feet wide (top) X 3 feet wide (bottom)]. Estimated upslope berm lengths for CS-53, CS-55, CS-59/CS-61, CS-63 and CS-64 are 600 feet, 900 feet, 100 feet (two 50 foot berms), 50 feet and 300 feet respectively.

<sup>5</sup> To be conservative, it is estimated that soils excavated for collection system sump and trench installation will be disposed of as hazardous mixed waste (\$450 per cubic yard transportation and disposal cost at the Nevada Test Site). The estimated volume of excavated soils is approximately 225 cubic yards and corresponds to the following: 40 cubic yards for CS-53 (sump), 43 cubic yards for CS-55 (sump and trench), 3 cubic yards for CS 59 (sump), 10 cubic yards for CS-61 (sump and weir), 42 cubic yards for CS-63 (sump and trench), and 87 cubic yards for CS-64 (2 sumps and trench expansion).

**TABLE 4-5 (cont )  
ASSUMED COSTS FOR SURFACE WATER DIVERSION  
AND COLLECTION SYSTEMS**

C	<u>OPERATION AND MAINTENANCE</u>		<u>CAPITAL COSTS</u> <u>(DOLLARS)</u>	<u>ANNUAL COSTS</u> <u>(DOLLARS)</u>
	<u>Quantity</u>	<u>Item</u>		
	6	<sup>6</sup> Collection System Cleaning		\$ 2,900
	-	<sup>7</sup> Sediment Disposal		4,300
	-	<sup>8</sup> Pipeline Maintenance		1,800
		<sup>9</sup> Power		1,400
		<sup>10</sup> Tank Truck Operation		60,600
		SUBTOTAL	\$320,800	\$ 71,000
D	<u>ENGINEERING AND CONTINGENCY</u>			
	Design at 25% of Capital Cost		\$ 80,200	
	Construction Management at 5% of Capital Cost		16,000	
	Contingency at 20%		64,200	14,200
		TOTAL COST	\$481,200	\$85,200

PRESENT WORTH

Present Worth Factor (PWF)	=	9 427 (30 years, 10%, for annual costs)
\$85,200/year x 9 427	=	\$ 803,200
1990 Capital Cost	=	<u>\$ 481,200</u>
		\$1,284,380

<sup>6</sup> Annual collection system cleaning costs are based on 48 manhours of labor at \$60/hr. Collection system cleaning involves removal of sediments that build up in the sumps and trenches.

<sup>7</sup> To be conservative, it is estimated that sediments recovered from collection system cleaning will be disposed of as hazardous mixed waste (\$450 per cubic yard transportation and disposal costs at the Nevada Test Site). The cost estimated is based on approximately 9.5 cubic yards of sediments recovered annually. This waste volume is based on an average suspended solids concentration of 350 ppm (see Section 4.4.1.1). It is assumed that approximately 20 percent of the suspended solids in the surface water will accumulate in the collection system sumps and trenches, and the resulting waste will be 30 percent solids by weight.

<sup>8</sup> Annual pipeline maintenance costs are based on 30 manhours of labor at \$60/hr.

<sup>9</sup> Annual electrical power costs are based on one 3-hp (CS-61) and one 1-hp (CS-59) liquid transfer pump(s) at \$0.07/Kwh.

<sup>10</sup> Tank truck operation costs for collection systems CS-53, CS-55, CS-63 and CS-64 are based on 120 mandays of labor at \$60/hr, plus \$25/day for gasoline and maintenance.

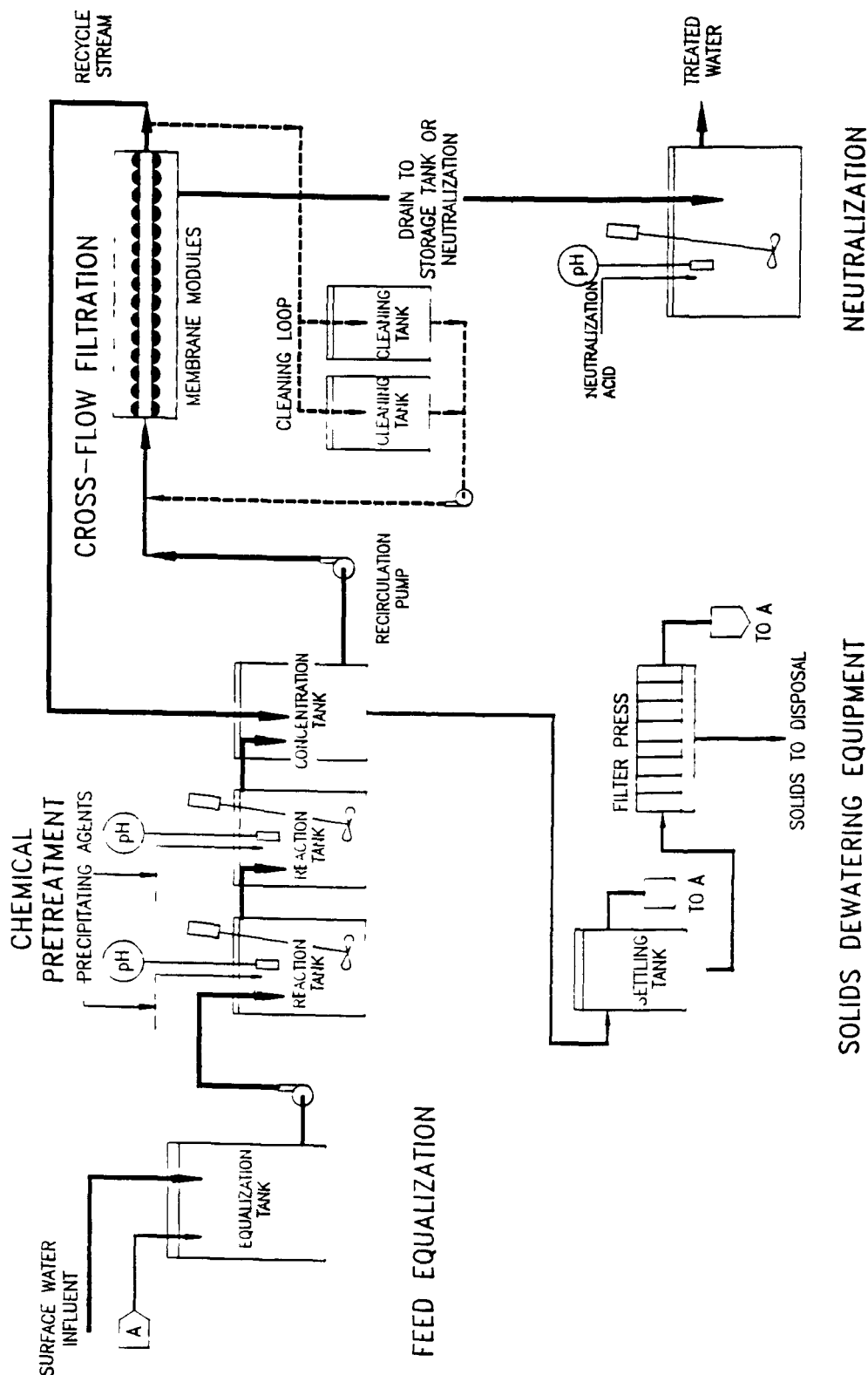


FIGURE 4-4

PROPOSED CROSS FLOW MEMBRANE FILTRATION SYSTEM SCHEMATIC

enmeshment in the hydrous metal oxide flocs. The pretreated feed combines with the recycle stream (2 to 5 percent solids) from the membrane filtration unit and is subsequently filtered mechanically. The membrane filter is in a shell and tube configuration with the membrane on the inside of the tubes. The permeate passes through the tubes perpendicular to the main flow at a low operating pressure. The flux through the filter is high relative to other membrane technologies, e.g., reverse osmosis and ultrafiltration, because of the large pore diameter of the filter. Flux rates of 200 to 400 gallons per square foot per day (gal/ft<sup>2</sup>/d) are typical for the membrane. A fraction of the recycle slurry is bled off for solids removal through gravity separation and mechanical dewatering. The permeate (flow passing through the filter) is neutralized by addition of sulfuric acid prior to discharge.

For the surface water IM/IRA, it is assumed for costing purposes that a modular and skid-mounted unit will be required with an assumed output capacity of 40 to 80 gpm and approximately 40 kilowatts (KW) of power. The unit would contain the following components:

- 2 1200-gallon reaction tanks,
- 1 3000-gallon concentration tank,
- 1 700-gpm recirculation pump
- 1 cleaning system, and
- 28 tubular membrane filtration modules

Auxiliary tanks and process equipment would include:

- 2 250-gallon chemical feed tanks,
- 1 1500-gallon solids sedimentation tank,
- 1 10-cubic-feet per day plate and frame filter press for sludge dewatering, and
- 1 10,000-gallon feed equalization tank

### Effectiveness

Cross-flow membrane filtration is effective at removal of suspended solids. There are numerous applications of this technology in use throughout the United States. Effluent suspended solids concentrations are less than 1 mg/l (Tiepel and Shorr, 1985). Because the radionuclides and metals are largely associated with the suspended solid fraction (see Section 4.4.2.1), simple suspended solids removal is anticipated to remove greater than 99 percent of these constituents. Toxicity of contaminated surface waters is thus significantly reduced in terms of potential future radionuclides and metals exposure, and it is likely that the ARARs will be achieved with the proper chemical feed. Treated water will be monitored to ensure contaminants are within regulatory guidelines. Cross-flow membrane filtration provides reliable and automated surface water treatment service requiring minimal operator intervention. Workers can be easily trained on the safe operation of the unit and handling of dewatered solids. This, together with health and safety design considerations (trailer venting, alarm/emergency shutdown systems, automated clean-in-place equipment, etc.) provides a high degree of worker protection. Sludges generated by the cross-flow membrane filtration process will be handled according to the RFP standard waste management procedures.

### Implementability

Cross-flow membrane filtration as described above has been used in industry and municipalities for wastewater treatment and for ground-water and surface water remediation since 1979. There are hundreds of units in operation today demonstrating that cross-flow membrane filtration is a reliable process. The high solids content of the recycle flow produces scour action on the membrane, minimizing fouling and thus the cleaning frequency (1 hour every 40 to 80 hours of operation). The membrane, an inert fluorocarbon material, can be cleaned with strong oxidants (hypochlorite) to remove bacterial films, or strong acids or bases to remove deposited metal hydroxides. The membrane will not degrade in the presence of the dilute concentrations of the solvents in the surface water. The equipment required to construct a cross-flow membrane filtration system is standard and readily available and special skills are not required for installation. Off-site permitted disposal facilities, are available for disposal of treatment residuals.

The demonstrated performance and anticipated effectiveness for remediating OU 2 surface waters should result in a high degree of public acceptance of cross-flow membrane filtration

### Costs

Assumed capital and operational costs for the cross-flow membrane filtration system are shown in Table 4-6. Note that since the economic analysis of the treatment alternatives is a comparative one, process stream monitoring and analysis costs are not included in the cost estimate for cross-flow membrane filtration or other treatment units examined in this section since these costs are common to all treatment units. In calculating sludge disposal costs, values for influent suspended solids concentration (350 ppm) and average annual year-round influent flow (20 gpm) were estimated. The influent suspended solids concentration is based on a flow-weighted average concentration calculation similar to that used for calculating the influent contaminant concentrations in Table 4-1. The suspended solids concentration data used in the computation was obtained from the 1987, 1988 and 1989 field investigations. An average year-round influent flow of 20 gpm was established based on the following rationale. The historical flow data used to establish the CS-61 design flow (i.e., Table 4-3 with the 166 gpm high precipitation related flows eliminated) indicates an average annual flow at SW-61 of less than 12 gpm. The flow at SW-61 represents more than two-thirds of the total design flow for the OU 2 surface water collection system. Therefore, the total average annual flow for the system is conservatively estimated at 20 gpm. A cross-flow membrane filtration system can be installed for \$486,500, with annual operation and maintenance costs of \$249,000 per year. Assuming a 10 percent interest rate and a 30-year operating life, the present worth of the system is \$2,833,500.

### 4.4.1.2 Granular Media Filtration

#### Description

The continuous backwash, continuous upflow sand filter was introduced to the United States in 1979 (Hetzer, 1987). As shown in Figure 4-5, polymer is injected into the surface water, followed by rapid mixing in an in-line static mixer. Water rises through the bed where flocculation, coagulation and floc removal occur. Clean water overflows a weir at the top of the sand bed. As the water rises, sand moves downward through



TABLE 4-6

## ASSUMED COSTS FOR CROSS-FLOW MEMBRANE FILTRATION PROCESS

<u>Item</u>	<u>Capital Cost (Dollars)</u>	<u>Annual Cost (Dollars)</u>
A      Cross-Flow Membrane Filtration Unit (60 GPM Design Flow)	\$216,100	

Includes

<u>Quantity</u>	<u>Item</u>
2	1200-gallon Reaction Tank with Mixer pH Controller and Metering Pump
1	3000-gallon Concentration Tank
1	700-gpm Recirculation Pump Membrane Filtration Modules Membrane Cleaning System <sup>1</sup> Electrical <sup>1</sup> Piping

## B      AUXILIARY EQUIPMENT

<u>Quantity</u>	<u>Item</u>	
1	10,000-gallon Equalization Tank	\$ 14,500
1	Lime Slurry System Includes 250-gallon Tank, Mixer, Recirculation Pump, Level Control	11,400
2	Powdered Chemical System Includes 250-gallon Tank, Mixer, Metering Pump	6,000
1	Neutralization System Includes 1500-gallon Tank, Mixer, Metering Pump pH monitor/controller	19,500
1	10-Cu Ft Filter Press Includes Feed Pump, Dumpster, Air Blowdown System	36,000
2	Trailer	44,000

TABLE 4-6 (cont )

## ASSUMED COSTS FOR CROSS-FLOW MEMBRANE FILTRATION PROCESS

<u>Item</u>	<u>Capital Cost (Dollars)</u>	<u>Annual Cost (Dollars)</u>
C	OPERATING COSTS	
<sup>2</sup> Operation and Maintenance		\$131,000
<sup>3</sup> Monitoring and Analysis		
<sup>4</sup> Power		24,500
<sup>5</sup> Sludge Waste Disposal		32,000
<sup>6</sup> Treatment Chemicals		20,000
SUBTOTAL	<u>\$347,500</u>	<u>\$207,500</u>
D	ENGINEERING AND CONTINGENCY	
Design at 15% of Total Capital Cost	\$ 52,100	
Construction Management at 5% of Total Capital Cost	17,400	
Contingency at 20%	<u>69,500</u>	<u>41,500</u>
TOTAL COST	<u>\$486,500</u>	<u>\$249,000</u>

Present Worth

Present Worth Factor (PWF) =	9 427 (30 years, 10%l for annual costs)
\$249,000/year x 9 427 =	\$2,347,000
1990 Capital Cost =	<u>486,500</u>
	\$2,833,500

- 1 Electrical and mechanical service for connections less than or equal to 10 feet are included in the cost of the basic system
- 2 Operation and maintenance for surface water treatment is based on one operator per shift, for three shifts per day at 2 hours per shift, seven days per week, at \$60/hour
- 3 Monitoring and analytical costs are not included because they are the same for all treatment technologies considered for the IM/IRA
- 4 Power cost estimate is based on a process power requirement of 40 KW, operated continuously at \$0 07/Kw-Hr
- 5 To be conservative in cost estimating, it is assumed that filter press sludge will be disposed of as a mixed waste (\$450 per cubic yard transportation and disposal cost at the Nevada Test Site) Annual production of filter cake is based on a daily average influent flow of 20 gpm containing approximately 350 ppm of suspended solids and the chemical additions noted in footnote 6 The filter cake produced is assumed to be 30% solids by weight with a density of 80 pounds per cubic foot
- 6 Chemical consumption costs are based on an average year-round influent flow of 20 gpm, 0 3 pounds of iron and 1 pound of lime required per 1,000 gallons of surface water treated

eg&amp;g\sw-irap\last\tables\tbl-4-6 aug

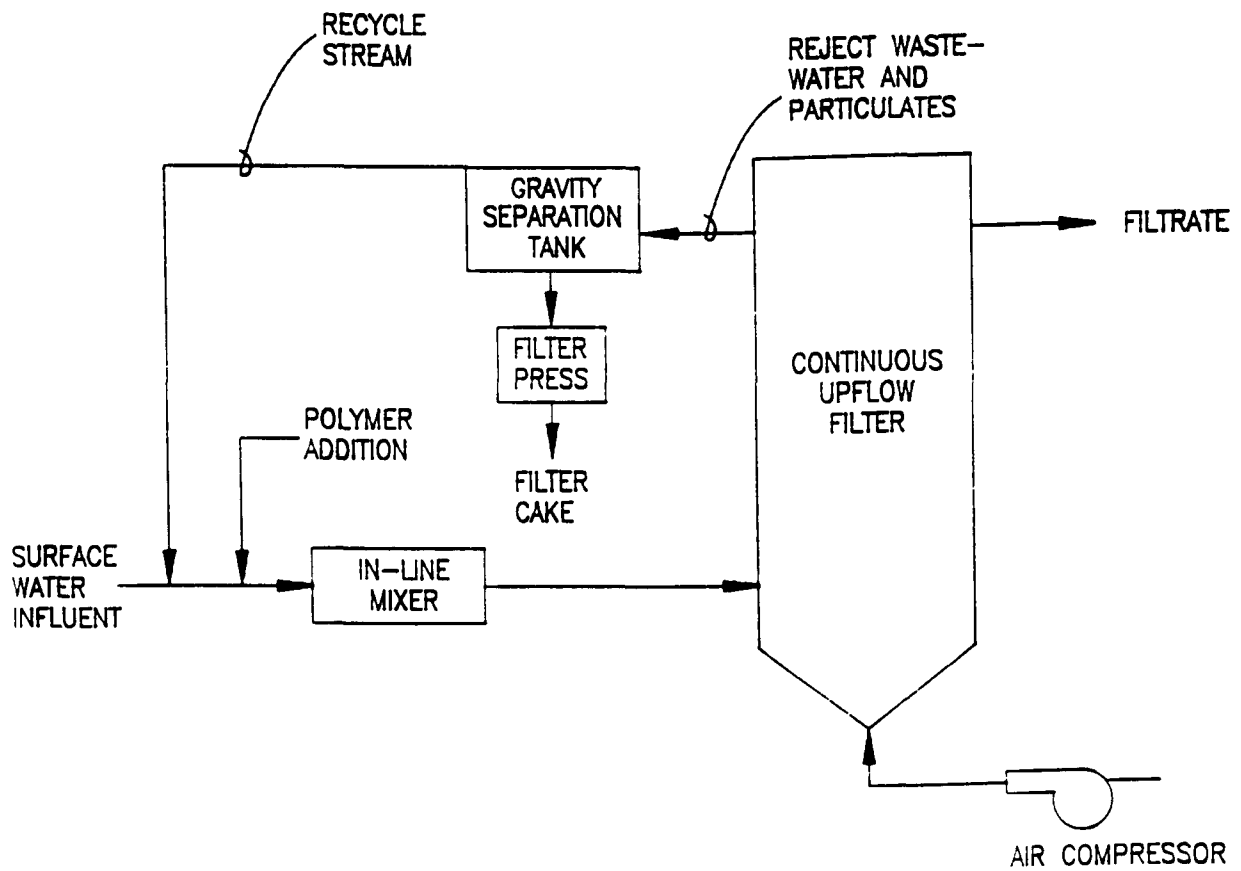


FIGURE 4-5  
GRANULAR MEDIA FILTRATION TREATMENT UNIT

the bed countercurrent to this flow of water. This downward motion is induced by an air lift system in the center of the bed (centralized pipe with air injection at the base) that draws the sand upward. Turbulent flow is created in this air lift, scouring the dirt from the sand. The dirt/sand slurry spills over at the top of the airlift into a compartment with a perforated bottom and overflow weir. The rapidly settling sand separates from the dirt in this compartment, and the clean sand is returned to the top of the sand bed. The dirty water exiting the filter would be directed to a sedimentation tank, and the overflow from this tank sent back to the filter. The solids from this tank will require dewatering and disposal waste management operating procedures. Continuous upflow sand filters are typically designed based on a hydraulic loading of 4-5 gpm/ft<sup>2</sup>. For the surface water IM/IRA, a packaged fiberglass unit with filtration area of 12 ft<sup>2</sup>, a diameter of 4 feet, a height of 12 feet with a sand bed depth of 40 inches (3.3 tons of sand), and requiring 0.5 to 1.5 standard cubic feet per minute (SCFM) of air at 15 to 25 pounds per square inch (psi) would be applicable. A 10,000-gallon settling tank as well as a sludge conditioning and dewatering system will also be required.

#### Effectiveness

Granular media filtration with polymer addition is as effective at removal of suspended solids as conventional flocculation/coagulation and rapid sand filtration. Plutonium, americium, metals and, to a lesser extent, uranium will be largely removed in this unit because plutonium and americium exist predominantly as colloids in natural waters (Orlandini, 1990). The unit operation equipment is simple in design, offers operational reliability, and requires no special skills for installation. Workers can be easily trained on the safe operation of the unit and handling of dewatered solids. This, together with health and safety design considerations, provides a high degree of worker protection. The effluent from this system will be suitable for subsequent downstream treatment for dissolved radionuclide, metals and organics removal.

#### Implementability

Granular media filtration with polymer addition is a demonstrated technology with regard to suspended solids removal. Continuous upflow sand filters are particularly suitable for small water treatment plants where operating personnel are limited. They operate continually without the need to be shut down for backwashing because it is self cleaning and has no moving parts. The unit operation equipment required (i.e., continuous

upflow filter, in-line static mixers, filter press, etc ) are standard and readily available The upflow filter with continuous backwash is available as a complete unit and a minimal amount of structural mounting and piping is required to place it into service Off-site permitted disposal facilities, are available for disposal of treatment residuals The demonstrated performance and anticipated effectiveness and reliability of granular media filtration should result in acceptance of the technology by the public

### Costs

Relative to conventional suspended solids removal, granular media filtration with polymer addition is cost effective in terms of both capital and operating expenses Assumed capital and operational costs for the continuous upflow sand filter and appurtenances are shown in Table 4-7 The system can be installed for \$167,100, with annual operation and maintenance costs of \$82,700 per year Assuming a 10 percent interest rate and 30-year operating life, the present worth of the system is \$946,700

## 4 4 2 Radionuclides and Metals Removal

### 4 4 2 1 Cross-Flow Membrane Filtration

### Description

The cross-flow membrane filtration system was previously discussed in Section 4 4 1 1 In this section the chemistry and removal mechanisms for radionuclides and metals, as applied to cross-flow membrane filtration, are discussed

There are five oxidation states of plutonium in aqueous solutions Pu(III), Pu(IV), Pu(V), Pu(VI), and Pu(VII) However, under the oxidizing and near-neutral conditions expected in the surface water, the Pu(IV) oxidation state is the most stable (Cleveland, 1979) Pu(IV) is practically insoluble under these conditions because it readily hydrolyzes to form  $\text{Pu}(\text{OH})_4(\text{s})$  and, upon loss of water, to produce the thermodynamically stable  $\text{PuO}_2(\text{s})$  This solid phase is a colloidal polymer of neutral or positive charge Increasing pH tends to reduce the charge density of the polymer, and at pHs above 9 it is presumed that the colloid becomes

**TABLE 4-7  
ASSUMED COSTS FOR GRANULAR MEDIA FILTRATION  
TREATMENT UNIT**

<u>Item</u>		<u>Capital Cost</u> <u>(Dollars)</u>	<u>Annual Cost</u> <u>(Dollars)</u>
<b>A EQUIPMENT</b>			
<u>Quantity</u>	<u>Item</u>		
1	Continuous Upflow Sand Filter	\$ 24,000	
1	10,000-Gallon Equalization Tank	12,500	
1	Air Compressor and Dryer	3,800	
1	Pump and Associated Piping	500	
1	10,000-Gallon Sedimentation Tank	12,500	
1	10-cubic feet per day filter press	44,000	
1	Trailer	22,000	
<b>B OPERATION AND MAINTENANCE</b>			
	<sup>1</sup> Operator and Maintenance		\$ 43,800
	<sup>2</sup> Monitoring and Analysis		
	<sup>3</sup> Power		2,600
	<sup>4</sup> Sludge Waste Disposal		22,000
	<sup>5</sup> Polymer Consumption		<u>500</u>
	<b>SUBTOTAL</b>	<b>\$119,300</b>	<b>\$ 68,900</b>
<b>C ENGINEERING AND CONTINGENCY</b>			
	Design at 15% of Total Capital Cost	\$ 17,900	
	Construction Management at 5% of Total Capital Cost	6,000	
	Contingency at 20%	<u>23,900</u>	<u>13,800</u>
	<b>TOTAL COST</b>	<b>\$167,100</b>	<b>\$ 82,700</b>

**PRESENT WORTH**

Present Worth Factor (PWF) = 9 427 (30 years, 10%l for annual costs)  
 \$82,700/year x 9 427 = \$779,600  
 1990 Capital Cost = 167,100  
**\$946,700**

- <sup>1</sup> Operating and maintenance costs are based on 2 manhours of labor per day at \$60/hour
- <sup>2</sup> Monitoring and analytical costs are not included because they are the same for all treatment technologies considered for this IM/IRA
- <sup>3</sup> Electric power costs are based on a 3 hp pump and a 2 kw air compressor at \$0 07 per kw
- <sup>4</sup> To be conservative in cost estimating, it is assumed that filter press sludge will be disposed of as a mixed waste (\$450 per cubic yard transportation and disposal cost at the Nevada Test Site) Annual production of filter cake is based on an average year-round influent flow of 20 gpm containing approximately 350 ppm of suspended solids The filter cake produced is assumed to be 30% solids by weight with a density of 80 lbs per cubic foot Rationale for a 20 gpm average annual influent flow and an average TSS influent concentration of 350 ppm is presented in Section 4 4 1
- <sup>5</sup> Polymer consumption costs are based on an average year-round influent flow of 20 gpm and 0 5ppm polymer concentration

negatively charged. This reduction in charge density and eventual conversion to an anionic form at pHs above 9 decrease its adsorption affinity for soils and thus increases its mobility in the soil/water environment. In solution, Pu(V) and Pu(VI) coexist as ions with the Pu(IV) polymer. At a pH of 8, the dominant ionic form of plutonium may be  $\text{PuO}_2\text{CO}_3\text{OH}^-$  occurring at a concentration of approximately  $10^{-12}\text{M}$  ( $1.5 \times 10^{-5}$  pCi/l). However, the solubility of plutonium can be increased through complexation with humic acids.

Americium has one oxidation state in aqueous solutions: Am (III). Under oxidizing and near-neutral conditions expected in surface water, Am (III) strongly complexes with colloidal material and should exist in the particulate fraction (Orlandini, 1990).

There are four oxidation states of uranium in aqueous solutions: U(III), U(IV), U(V), and U(VI) (Sorg, 1987). U(III) and U(V) are unstable, and U(VI) is the thermodynamically predicted oxidation state of uranium under oxidizing conditions. U(VI) predominantly exists as the uranyl ion ( $\text{UO}_2^{2+}$ ). The uranyl ion readily complexes with the common anions chloride, sulfate, nitrate, and carbonate. In water with carbonate alkalinity and a pH range of 7-10, the dominant soluble species of U(VI) are  $\text{UO}_2(\text{CO}_3)_2^{2-}$  and  $\text{UO}_2(\text{CO}_3)_3^{4-}$ . At pH exceeding 9.5, the uranium hydroxide complex  $(\text{UO}_2)_3(\text{OH})_5^+$  becomes predominant. Unlike plutonium, uranium is significantly more soluble in water.

Soluble plutonium, americium, uranium and metals are removed from solution in the cross-flow membrane filtration process by adsorption on a ferric hydroxide floc. The most effective removal of uranium by conventional coagulation using iron salts is at a pH greater than 9.5. This is presumed to be due to the predominance of the positively charged uranium hydroxide ion in the presence of the negatively charged ferric hydroxide (Sorg, 1987). Because the predominant form of plutonium and most metals in the surface water is particulate, the cross-flow membrane filtration process will remove this radionuclide from the influent through adsorption to, and enmeshment in, the ferric hydroxide.

Ferric sulfate [ $\text{Fe}_2(\text{SO}_4)_3$ ] is the iron salt of choice for introducing ferric iron to the influent stream. Because of the hydrolysis of ferric iron, the pH drops to 2 or 3, which facilitates dissolution of the iron salt. The ferric sulfate is automatically fed in dry form to the influent in reaction tank No. 1 (see Figure 4-5). The ferric ion will rapidly hydrolyze at high pH (9 to 11) to form ferric hydroxide  $\text{Fe}(\text{OH})_3(\text{s})$ . Hydrated lime [ $\text{Ca}(\text{OH})_2$ ]

is automatically added in reaction tank No 2, and is used to raise the pH, which also improves the compressibility of the ferric hydroxide sludge. In surface water treatment applications, iron and lime consumption is typically 0.3 lbs and 1 lb, respectively, per 1,000 gallons of influent. These estimates will be made more exact based on the bench and field-scale treatability studies described in Section 6. An adjustment with a pH controller will be required prior to discharge of the permeate to maintain the effluent in a pH range of 6 to 9.

### Effectiveness

Although limited, there is data demonstrating the removal of plutonium from water using cross-flow membrane filtration. The only data available is from a study performed at the RFP using a small-scale, cross-flow membrane filtration unit (< 1 gpm) treating plutonium- and uranium-contaminated laundry wastewater. Results are shown below:

<u>Parameter</u>	<u>Concentration (pCi/l)</u>	
	<u>Influent</u>	<u>Effluent</u>
Gross alpha	2,480	5.3
Gross beta	3,933	8.9
Total uranium	1,238	2.25
Plutonium	63.4	0.25

The plutonium removal efficiency indicated by these test results is greater than 99 percent. Other data from previous test runs on laundry waste water indicated effluent plutonium concentrations less than the detection limit (0.1 pCi/l). Considering the complexing agents present in laundry water, it is possible that the cross-flow membrane filtration process can meet the ARAR for plutonium of 0.05 pCi/l. Using the percent plutonium removal for the above reported test and the expected influent concentration of plutonium to the treatment facility, the ARAR will be achieved based on theoretical calculations.

Data demonstrating removal of americium from natural waters is not available at the time of this writing. However, americium's strong affinity for particulates in natural waters suggests that americium should be removed from OU 2 surface waters by cross-flow membrane filtration via the suspended solids removal mechanisms. This observation is supported by examination of the dissolved and total americium



concentrations detected in OU 2 surface water samples (Appendix B) Examination of these data reveals that there were no instances where dissolved americium concentrations exceeded the ARAR Total americium concentrations (i.e., dissolved plus particulate), however, exceeded the ARAR on several occasions

Because of its ubiquity in water supplies, there is considerably more information on the removal of uranium during water treatment Uranium removal efficiencies have been reported for conventional coagulation/filtration water treatment, and data exist for cross-flow membrane filtration used at the RFP and at Uranium Mill Tailings Remedial Action (UMTRA) sites The UMTRA project is a DOE-sponsored program to clean up low-level radioactive uranium mill tailings and associated contaminated surface water runoff in eleven western states and Pennsylvania With regard to conventional water treatment, using a dose of 10 mg/l of ferric sulfate as a coagulant with a pH of 10, 80 percent removal of uranium has been reported (Sorg, 1987) Use of ferrous sulfate at doses between 20 to 25 mg/l and at the same pH resulted in removals as high as 92 to 93 percent For cross-flow membrane filtration, the above-reported test at the RFP indicates achieving greater than 99 percent removal and meeting the ARAR for uranium (10 pCi/l) At the Canonsburg UMTRA site, water containing 4,400 pCi/l of total uranium was treated to achieve a total uranium concentration of less than 1 pCi/l Although specific data is unavailable, the cross-flow membrane filtration unit operating at the Durango UMTRA site is achieving effluent uranium concentrations below the Colorado in-stream standards for that area

It would appear that cross-flow membrane filtration should be effective for removal of plutonium, americium and uranium as well as other metals from the surface water at OU 2 ARARs should be achieved for plutonium, americium and uranium, although there is less data and correspondingly less certainty on the performance of the system for plutonium and americium removal ARARs for gross alpha and gross beta should also be achieved The gross alpha is largely from uranium and particulate forms of plutonium and americium, and most of the gross beta arises from uranium 238 daughters, e.g., thorium 232 and protactinium 234 The thorium and protactinium predominantly exist in the particulate fraction and should be removed by cross-flow membrane filtration via adsorption on iron hydroxide Although cesium 137, potassium 40, lead 210, and strontium 90 (which are more soluble), also contribute to gross beta activity, the success of the current filtration operation to lower the gross beta concentration at Pond B-5 would indicate that they are not significant contributors to the gross beta activity in South Walnut Creek Removal of the radionuclides should effectively

reduce the potential threat to the public health and the environment. The ARAR for TDS may not be achieved with cross-flow membrane filtration as a result of the addition of ferric sulfate and lime to the process influent.

The ARAR for TDS is not a public health-based standard, rather, it is a secondary drinking water standard set for aesthetic reasons. The bench and field-scale treatability studies will provide TDS concentration data of treated effluent.

#### Implementability

See Section 4.4.1.1 for a discussion of the implementability of the cross-flow membrane filtration process.

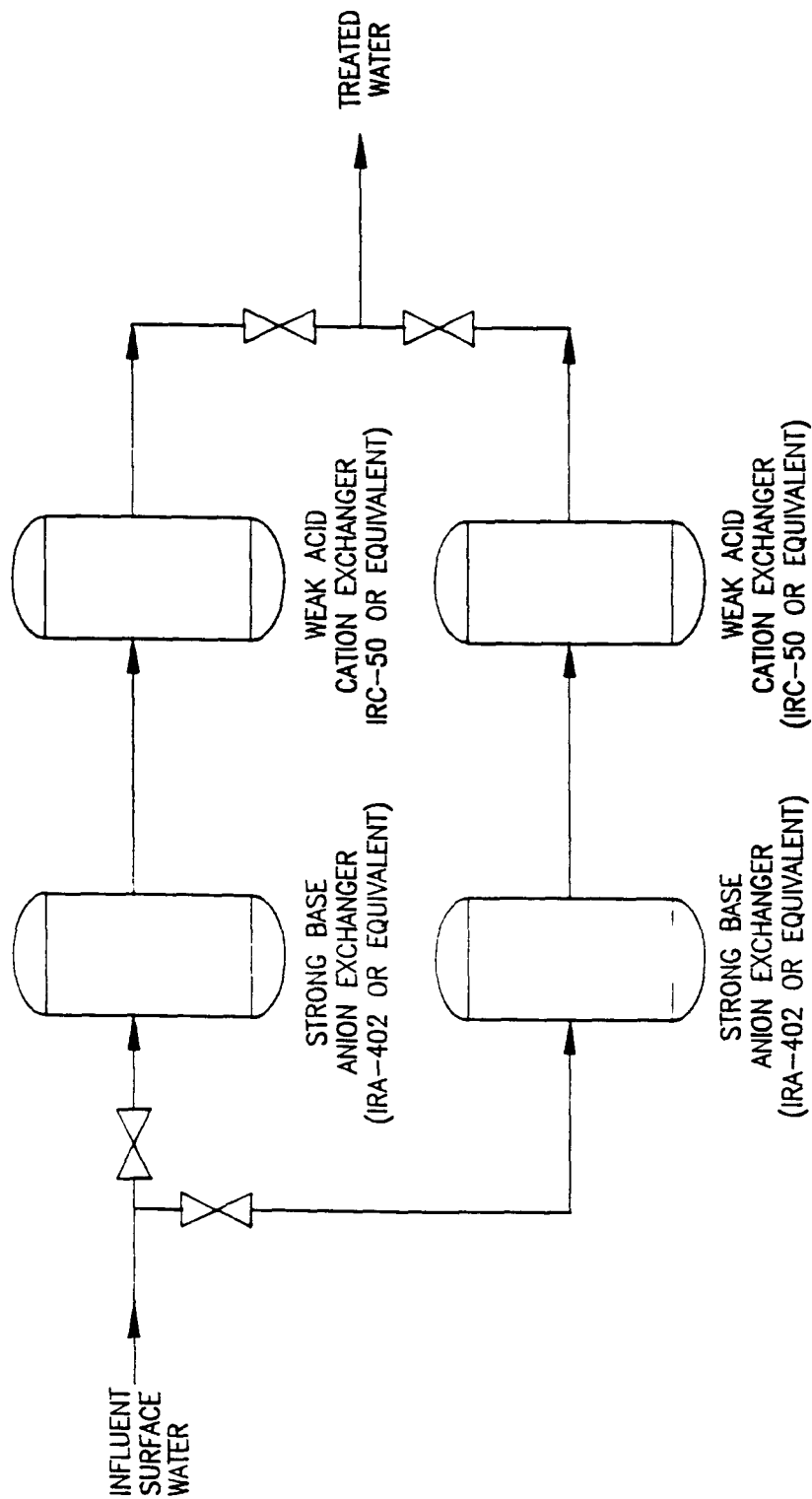
#### Costs

See Section 4.4.1.1 (Table 4-6) for a presentation of the assumed capital and operating and maintenance costs of the cross-flow membrane filtration process.

### 4.4.2.2 Ion Exchange

#### Description

The ion exchange treatment system for the removal of radionuclides consists of a strong, base anion exchanger followed by a weak acid cation exchanger (Figure 4-6). These exchangers are designed for the removal of uranium and plutonium, respectively. Both ion exchangers have been designed conservatively using a hydraulic loading less than 5 gpm/ft<sup>2</sup> and a bed capacity less than 2 gpm/ft<sup>3</sup>. This translates to a 4-foot diameter column with a resin bed depth of 3 feet. The column will include 100 percent freeboard. This freeboard is necessary for resin expansion during regeneration or for backwashing if required.



ON-LINE, STAND-BY UNITS

**NOTES**

- 1 STRONG BASE ANION EXCHANGE RESIN IRA-402 IS MANUFACTURED BY ROHM AND HAAS COMPANY
- 2 WEAK ACID CATION EXCHANGE RESIN IRC-50 IS MANUFACTURED BY ROHM AND HAAS COMPANY

**FIGURE 4-6**  
**ION EXCHANGE TREATMENT SYSTEM**

The strong base anion exchanger will contain 37.5 ft<sup>3</sup> of Rohm and Haas IRA-402 resin or equivalent in the chloride form. Regeneration will not be required because of the high affinity and capacity of the resin for uranium. The expected life of the unit is greater than 30 years at the expected influent uranium concentration. Although other anions will be adsorbed to the resin, the preferential adsorption of uranium over other anions in solution will, over time, displace these anions. The spent resin will ultimately require solidification and disposal at the Nevada Test Site.

The cation exchanger will contain 37.5 ft<sup>3</sup> of Rohm and Haas IRC-50 weak acid cation exchange resin or equivalent in the sodium form. This resin has a high affinity for high molecular weight metals, e.g., mercury, copper, lead, and zinc. Published information on the removal of plutonium from natural waters by ion exchange has not been found. A cation exchange resin with a high affinity for heavy metals is most likely to remove plutonium because the plutonium will predominantly exist as a colloid carrying a positive charge. The performance of ion exchange for the removal of plutonium is unknown, however, it is noted that most of the plutonium should be removed during upstream suspended solids removal. There is insufficient information to determine the frequency at which the resin will require regeneration. It is assumed that, like the anion exchanger, the cation exchanger will not require regeneration over the life of the interim action.

#### Effectiveness

Ion exchange has been proven to remove heavy metals and uranium from water to meet the ARARs, whereas plutonium and americium removal using this technology is unproven. Ion exchange has been used to remove uranium from mine water for many years and has been studied extensively by EPA for the removal of uranium from drinking water (Sorg, 1987). Ion exchange is commonly used for the removal of plutonium from strong acid solutions, but no information exists on the use of ion exchange for the removal of plutonium (or americium) present in natural waters. The absence of plutonium and americium removal efficiencies in ion exchange does not allow conclusions to be drawn with regard to its effectiveness in reducing the toxicity of influent OU 2 surface waters, and thus, protection of human health and the environment and public health.

An ion exchange system is for the most part a self-contained and automated operation. Workers may be easily trained on the safe operation of the system. There is uncertainty as to whether the cation exchanger

(i.e., plutonium and americium removal) will require regeneration. This lends uncertainty as to the volume of treatment residuals that will be generated as well as the degree of worker exposure in handling the regeneration wastes. The anion exchanger will not require regeneration, as discussed earlier, as the uranium carbonate complex will preferentially displace major ions that will initially load onto the resin.

#### Implementability

Ion exchange is a well established technology that has demonstrated long-term reliability and performance in water treatment and after applications. The vessels, piping and pumps required to construct a system are commercially available, off-the-shelf items. The anion and cation exchange resins, however, are specific to each application and, as suggested above, effective resins for plutonium and americium removal from surface waters may not be readily available. If the weak acid cation exchanger requires regeneration (i.e., plutonium and americium removal), an acid regeneration system would be required, and the wastewater from regeneration would require storage and treatment at the Building 374 Process Waste Treatment System (chemical precipitation/flash evaporation). If regeneration of the cation exchange resin is not required, operation and maintenance requirements for the system will be low. Effluent would be routinely monitored for breakthrough of the radionuclides shown in Table 4-1. The removal of suspended solids in a pretreatment step is required to prevent fouling of the resin.

At this time, the degree of uncertainty associated with plutonium and americium removal suggests the public will not readily accept ion exchange as a preferred treatment technology. Demonstration of technical feasibility through treatability study testing is necessary.

#### Costs

Assumed capital and operational cost for the ion exchange system is shown in Table 4-8. Costs for pretreatment of the influent for removal of suspended solids are not considered in Table 4-8. The system can be installed for \$289,900, with annual operation and maintenance costs of \$45,400 per year. The operation and maintenance cost assumes that regeneration of the weak acid cation exchange resin will not be required. At an interest rate of 10 percent and an operating life of 30 years, the present worth of the system is \$717,900.

**TABLE 4-8**  
**ASSUMED COSTS FOR ION EXCHANGE**  
**TREATMENT SYSTEM**

<u>Item</u>		<u>Capital Cost</u> <u>(Dollars)</u>	<u>Annual Cost</u> <u>(Dollars)</u>
<b>A      EQUIPMENT</b>			
<u>Quantity</u>	<u>Item</u>		
2	Strong Anion/Weak Cation Exchange Treatment System	\$ 160,000	
1	2500-gallon Regeneration Waste Storage Tank	3,000	
2	Trailer	\$ 44,000	
<b>B      OPERATION AND MAINTENANCE</b>			
	<sup>1</sup> Operation and Maintenance		36,000
	<sup>2</sup> Power		1,800
	<sup>3</sup> Monitoring and Sampling		
	<b>SUBTOTAL</b>	<b>\$ 207,000</b>	<b>37,800</b>
<b>C      ENGINEERING AND CONTINGENCY</b>			
	Design at 15% of Capital Cost	\$ 31,100	
	Construction Management at 5% of Capital Cost	10,400	
	Contingency at 20%	<u>41,400</u>	<u>7,600</u>
	<b>TOTAL</b>	<b>289,900</b>	<b>45,400</b>

**PRESENT WORTH**

Present Worth Factor (PWF) =	9 427 (30 years, 10%i for annual costs)
\$ 45,400/year x 9 427 =	\$ 428,000
1990 Capital Cost	<u>289,900</u>
	\$ 717,900

- 1      Operation and maintenance costs are based on 50 manhours of labor per month at \$ 60/hour
- 2      Power estimates are based on two 2-hp process pumps operated continuously at \$ 0 07 per kwh
- 3      Monitoring and analytical costs are not included because they are the same for all treatment technologies considered for the IM/IRA

#### 4 4 3 Organic Contaminant Removal

##### 4 4 3 1 Activated Carbon Adsorption

###### Description

With a GAC adsorption system, the surface water will be pumped through two GAC columns in series and operated in downflow fixed-bed mode (Figure 4-7). A second set of GAC columns will be maintained in stock. Each carbon column is 60 inches in diameter and 87 inches high, and contains 2000 pounds of carbon. Based on a flow rate of 60 gpm, the hydraulic loading to each column will be approximately 3 gpm/ft. The empty bed contact time for each column will be approximately 18 minutes.

To completely utilize the carbon, columns are arranged in series, allowing the lead column to become fully exhausted before regeneration while the second (polishing) column ensures effluent quality. Periodic samples will be taken from the effluent of each unit, and when the lead unit effluent exceeds ARARs, the lead carbon column will be removed, the polishing (second) column will become the lead column, and a stock carbon unit will be put in service as the polishing unit. The carbon column with the exhausted carbon will then be shipped to an off-site location for regeneration.

###### Effectiveness

GAC adsorption systems have been shown to remove VOCs from contaminated water to levels that comply with the ARARs. The EPA (*Federal Register*, Vol. 52, No. 130, page 25698) has designated carbon adsorption a "Best Available Technology" for the removal of seven specific volatile organic compounds from drinking water which includes common chlorinated solvents. This assumes that vinyl chloride, methylene chloride, and acetone are not present at the proposed OU 2 surface water collection locations since these compounds are not readily adsorbed from solution using activated carbon. The surface water quality data presented in Appendix B indicates that these compounds were detected at levels above ARARs only at Upper South Walnut Creek stations SW-56, SW-60 and SW-101. It is proposed, however, that surface water

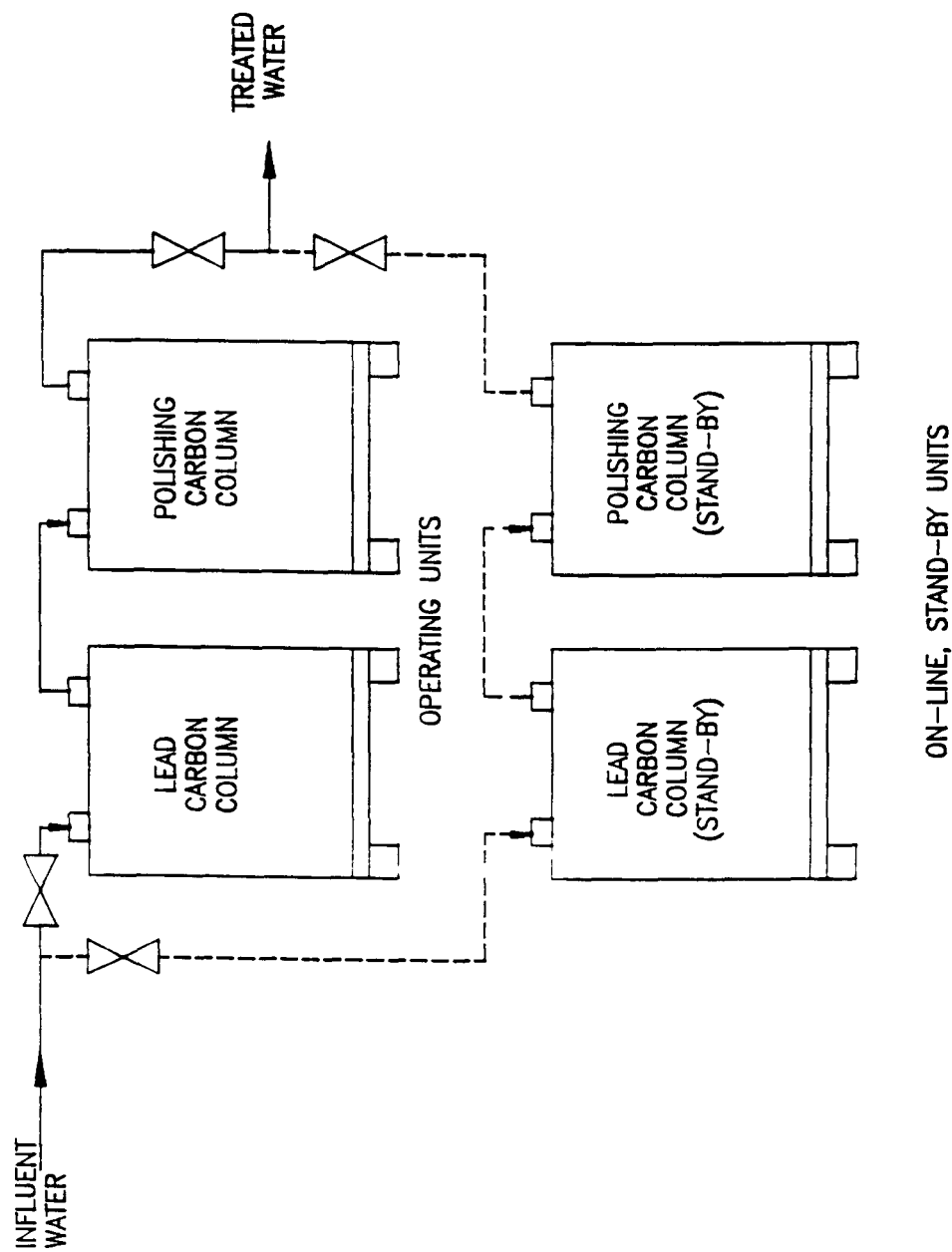


FIGURE 4-7  
CARBON ADSORPTION TREATMENT UNIT



be collected at the downstream station SW-61 where vinyl chloride, methylene chloride and acetone have always been estimated below detection limits and/or were also present in the associated laboratory blanks

The probability of equipment failure will be minimized in this system because of the redundancy of having standby lead and polishing adsorption units in parallel to the operating units, each of which could treat the design flow. Two additional stock units on site add to the system reliability. Appropriate safety measures required when moving and installing large equipment will be complied with during installation. The operation and maintenance of the system will be by personnel who are trained in the handling of hazardous and radioactive wastes. Wet activated carbon preferentially removes oxygen from the air. Therefore, any time personnel are working in confined areas where oxygen may be depleted, appropriate sampling and work procedures for potentially low-oxygen spaces will be followed, including all applicable federal and state requirements.

The operators of the GAC system will not be exposed to VOC-laden carbon because the use of the containerized and transportable carbon contactors allows removal and regeneration/replacement of the exhausted carbon at a remote carbon reactivation site. Carbon will not be handled at the site. Transporting the entire exhausted carbon column to the regeneration facility ensures operators are protected from the carbon, and the operators need only follow routine safety procedures which are appropriate to handling heavy equipment.

The exhausted carbon is generally regenerated through a thermal treatment process which strips the volatile organics from the carbon. The organics are subsequently destroyed via incineration. During this regeneration process, a small quantity of ash may be generated which requires disposal at a landfill. Thus, this process can be considered an alternative to land disposal since the carbon is continuously recycled.

GAC adsorption treatment in sealed, fixed-bed contactor vessels does not produce any waste streams or vapor emissions. The safety of nearby communities should not be adversely affected and the risk of harm to the environment should not be increased. This treatment process will effectively remove many of the target

organic contaminants from the surface water. Treated water will be monitored at the effluent and also at an intermediate point in the system to ensure contaminants are below the ARAR concentrations before being released to South Walnut Creek during implementation of the process.

#### Implementability

GAC adsorption is a proven technology for reducing many VOCs from water. Testing performed by Calgon (Rockwell International, 1988b) demonstrated that activated carbon can remove VOCs to meet ARARs. A second carbon unit connected in series with the lead unit would serve as a polishing unit and will ensure removal of the VOCs to these levels. The removal of suspended solids in a pretreatment step is required to prevent fouling of the carbon. The carbon columns can be easily shipped and readily installed. The system should be ready to operate at full capacity after initial adjustments and test runs. Carbon services that provide rental and regeneration of carbon columns are common and offer an alternative to a capital purchase. A high degree of public acceptance is anticipated for GAC adsorption based on its BDAT classification, and the minimal generation of treatment residuals. These services are readily available and cost effective for an interim action.

#### Costs

It is estimated that the carbon usage rate will be 0.6 pounds per 1,000 gallons of surface water, based on breakthrough of 1,1-DCA. This assumes that vinyl chloride, methylene chloride, and acetone are not present at SW-61. Based on a maximum wet surface flow rate of 60 gpm, the annual consumption of carbon will be approximately 20,000 pounds. The cost of a 20,000-pounds-per-year carbon service is \$50,000. This includes the rental and regeneration of 10 carbon columns, each containing 2,000 pounds of activated carbon. The cost of round-trip shipping is estimated at \$3,000 per column. It is assumed that the exhausted carbon columns will be shipped as a manifested hazardous waste.

Using the preceding information, the assumed capital cost for installing a carbon adsorption system is \$70,600, and the assumed annual operating cost is \$164,900 as shown in Table 4-9. Costs for pretreatment of the influent for removal of suspended solids are not considered in Table 4-9. Total cost (present worth) of

TABLE 4-9

**ASSUMED COSTS FOR GRANULAR ACTIVATED  
CARBON TREATMENT SYSTEM**

<u>Item</u>	<u>Capital Cost (Dollars)</u>	<u>Annual Cost (Dollars)</u>
<b>A      EQUIPMENT</b>		
<u>Quantity</u> <u>Item</u>		
1      Process Piping and Pump	3,000	
1      Trailer	44,000	
<b>B      OPERATION AND MAINTENANCE</b>		
<sup>1</sup> Activated Carbon Service		\$ 50,000
<sup>2</sup> Shipping		30,000
<sup>3</sup> Power		1,800
<sup>4</sup> Operation and Maintenance		<u>55,600</u>
SUBTOTAL	\$ 47,000	\$ 137,400
<b>C      ENGINEERING AND CONTINGENCY</b>		
Design at 25% of Total Capital Cost	\$ 11,800	
Construction Management at 5% of Total Capital Cost	2,400	
Contingency at 20%	<u>9,400</u>	<u>27,500</u>
TOTAL	\$ 70,600	\$ 164,900

PRESENT WORTH

Present Worth Factor (PWF) =	9 427 (30 years, 10% i for annual costs)
\$ 164,900/year x 9 427 =	\$ 1,554,500
1990 Capital Cost =	<u>70,600</u>
	\$ 1,625,100

- <sup>1</sup> Activated carbon service costs are based on rental and regeneration of ten 2,000-pound carbon columns at \$ 5,000 per column
- <sup>2</sup> Shipping costs are based on 10 round trip column shipments per year at \$3,000 per round-trip shipment
- <sup>3</sup> Power costs are based on one 4-hp pump @ \$0.07/kwh
- <sup>4</sup> Operation and maintenance costs based on 77 manhours of labor per month @ \$60/hour

the GAC adsorption system based on 10 percent simple interest, a 30-year duration of operation, and no salvage value, is estimated to be approximately \$1,625,100

#### 4 4 3 2 Ultraviolet (UV) Peroxide Oxidation

##### Description

The UV/peroxide treatment unit, as designed by one manufacturer, consists of an 360-gallon, stainless-steel oxidation chamber which provides for a surface water retention time range of 4 to 8 minutes at a peak system flowrate of 60 gpm (Figure 4-8)

The oxidation chamber contains UV radiation lamps which are mounted horizontally in quartz sheaths. A hydrogen peroxide feed system is used to inject approximately 50 mg/l (per ppm of organic contaminants) of a 50 percent  $H_2O_2$  solution into the surface water feed line. The surface water/peroxide mixture then passes through an in-line static mixer before entering the bottom of the oxidation chamber. The water then flows through the reaction chamber, passing the UV lamps, before it exits the top of the oxidation chamber.

##### Effectiveness

The UV/peroxide system is capable of removing VOCs from the surface water to levels below the ARARs. A technology evaluation of a demonstration unit was conducted by the EPA's Risk Reduction Laboratory in Cincinnati, Ohio. Ground-water treatment experiments were performed in which residence time, ozone and hydrogen peroxide dosages, radiation intensity and influent pH were altered to evaluate the technology. The demonstration unit achieved VOC removals greater than 90 percent. These results indicate that the UV/peroxide treatment process is likely capable of achieving the effluent criteria for all of the volatile organics listed in Table 4-1. However, the volatile organics may not be completely oxidized to carbon dioxide, water, and chloride, and unintended organic degradation products may be produced.

The system requires periodic UV lamp replacement and routine maintenance, and with such maintenance, the unit is expected to have long-term reliability. The risk of failure of the system at any time is

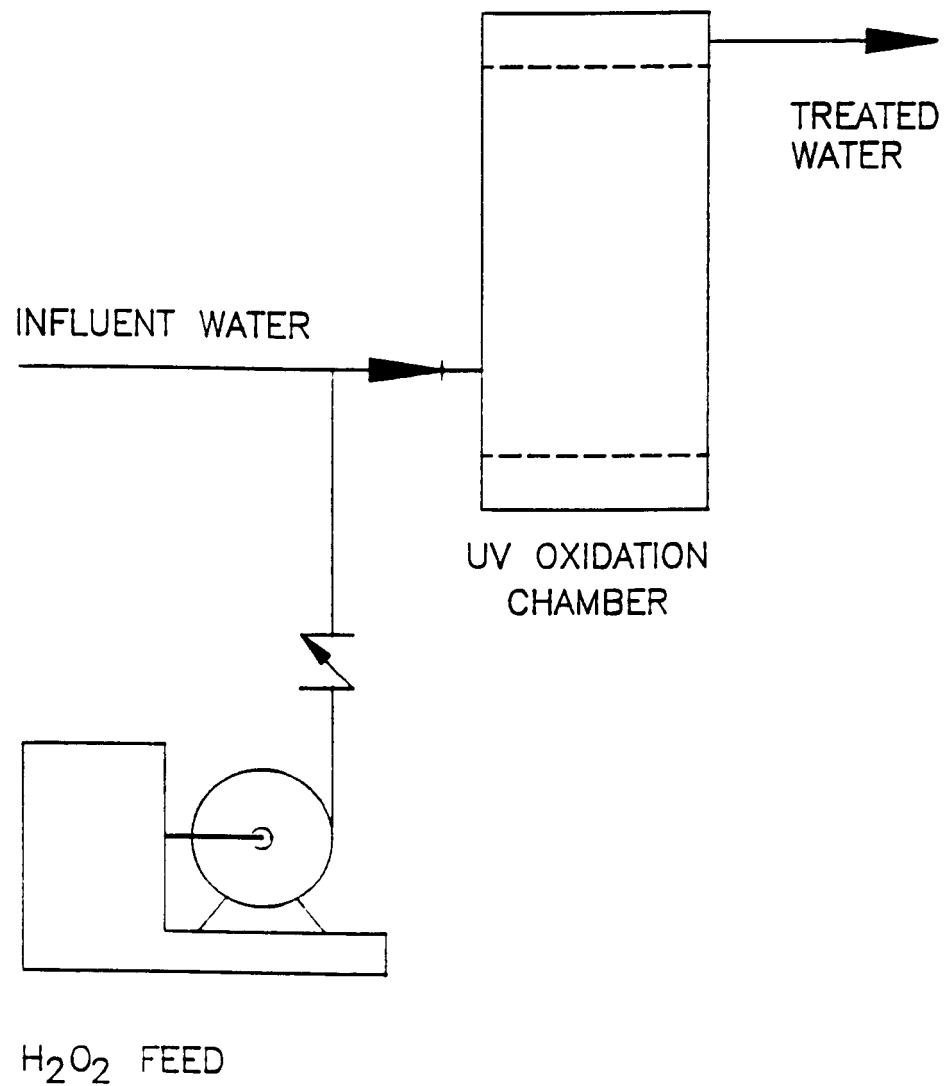


FIGURE 4-8  
UV/PEROXIDE SYSTEM

highly unlikely. However, because surface water is expected to have widely varying concentrations of organics, it will be difficult to ensure adequate peroxide dosage for complete organic destruction and to prevent the appearance of excess peroxide in the effluent. While the presence of ferrous iron and manganese can impede the effectiveness of the UV/peroxide treatment system due to the precipitation of these metals, a manufacturer has indicated that this will not be a problem at the iron and manganese concentrations expected. However, should precipitation problems arise, appropriate pretreatment and posttreatment will be implemented to correct this problem.

The UV/peroxide oxidation system will destroy VOCs present in contaminated OU 2 surface water and thus represents an alternative to land disposal. The system itself will not produce treatment residuals. Some support unit operations (i.e., pre-treatment) for the UV/peroxide oxidation system, however, may require residual waste management.

During operation of the UV/peroxide oxidation treatment unit, the use of hydrogen peroxide, a strong oxidizer, will require that operators be aware of this potential hazard. The  $H_2O_2$  bulk storage tank will be properly vented to assure no pressure buildup and minimize handling exposure. Existing DOE and EG&G health and safety guidelines at the RFP regarding operator safety while working with strong oxidizers will be followed. UV lamps operate utilizing high voltage, and thus caution must be used when working with the system and during the periodic replacement of the UV lamps.

The safety of nearby communities should not be adversely affected, and the risk of harm to the environment should not be increased as this treatment process will effectively destroy the contaminants. Treated water will be monitored to ensure contaminants are within regulatory guidelines before being released to the environment.

#### Implementability

UV/peroxide oxidation is a technology for the complete destruction and detoxification of hazardous organic compounds in aqueous solutions. Although the technology is relatively new and has had limited application in the field, SARA requires EPA to prefer remedial actions that significantly and permanently reduce

the toxicity, mobility, or volume of hazardous wastes by employing innovative technologies that result in the destruction or detoxification of the wastes. The equipment necessary to construct a UV Peroxide systems is not "off-the-shelf", but must be designed for each individual application. The equipment components and materials necessary to construct a system are readily available, however.

Demonstrated performance of the UV/peroxide ground-water treatment system has been somewhat limited due to the relatively new development of the process. However, there are six UV/peroxide units currently operational or on-line and ready for operation. One of these units is located at Rocketdyne's Santa Susana facility in southern California. Pilot-scale operations were performed on ground water containing VOCs (TCA, TCE, etc.) at system flow rates of approximately 20 to 40 gpm. Results from the pilot scale testing were favorable, and a UV/peroxide ground-water treatment unit has been purchased, set up, and site tested. Another UV/peroxide ground-water treatment system, located locally, was visited and appeared to be a low-maintenance, highly effective ground-water treatment unit. This system was treating ground water with TCA concentrations significantly lower than those found at the 881 Hillside (approximately 7 ppb). However, the same UV treatment process had initially and effectively treated ground water with much higher concentrations.

Operating and maintenance requirements for the UV/peroxide treatment system are relatively minor. The system will require up to 500 kW of power, a high electrical power consumption requirement relative to other treatment processes, and 12,200 pounds/year of 50 percent  $H_2O_2$  solution for normal operation. Routine maintenance of the equipment is required and the UV lamps will require replacement approximately every six months. All four system UV lamps can be exchanged in about an hour. Influent pretreatment for suspended solids removal is required to prevent fouling of the oxidation chamber. Also, influent pre- and post-treatment for removal of iron and manganese may be necessary as discussed above. The system will require careful observation to ensure the system is operating properly, although system alarms will notify operators if a problem does occur.

Public acceptance of UV/peroxide oxidation should be favorable based on removal efficiencies observed to date. The attribute of mineralizing VOCs present in surface water (i.e., converting them to carbon dioxide and water) should also receive a favorable response. Treatability testing on OU 2 surface water contamination may be necessary to win public approval since it is still a relatively new technology.

## Costs

Assumed costs for the UV/peroxide ground-water treatment unit are shown in Table 4-10. Costs for pre- and post-treatment of the influent for reasons discussed above are not considered in Table 4-10. The capital cost for the UV/peroxide surface water treatment system is approximately \$672,800. Operational costs are \$214,600 per year and include procurement of hydrogen peroxide, power utilization, labor, and lamp replacement. Operational costs are based on a system flow rate of 60 gpm, 24 hours per day. Assuming a 10 percent interest rate and a 30 year operating life, the present worth of the system is \$2,695,500.

### 4.4.3.3 Air Stripping with Off-Gas Treatment

#### Description

During air stripping, VOCs are transferred from the water to a continuously flowing airstream which is in direct contact with the water (Figure 4-9). Influent contaminated surface water will enter the top of a 32-inch diameter, 34-foot air stripping column and subsequently contact clean air supplied through the bottom of the column (column sizes are approximate). Appropriate air-to-water flow rates will be utilized to provide for the optimum (99+ percent) transfer of the contaminants from the surface water to the air stream. The treated surface water will then be pumped through a 2000-pound liquid phase carbon treatment polishing unit (identical to the one described in Section 4.4.3.1). The air stripper emissions will be heated above dew point and then passed through a vapor phase carbon system to remove the organics before being released to the environment. The vapor phase carbon unit will contain 2,000 pounds of carbon.

#### Effectiveness

The use of an air stripper is a highly effective method of removing hazardous VOCs from water. The efficiency of the process is well documented. The Environmental Protection Agency (*Federal Register*, Vol. 52, No. 130, page 25698) has designated packed tower aeration along with granular activated carbon, as a BDAT for the removal of VOCs from drinking water.



TABLE 4-10

**ASSUMED COSTS FOR UV PEROXIDE OXIDATION  
TREATMENT SYSTEM**

		<u>Capital Cost (Dollars)</u>	<u>Annual Cost (Dollars)</u>
A	EQUIPMENT		
<u>Quantity</u>	<u>Item</u>		
1	UV Peroxide Oxidation Treatment Unit	420,000	
2	Trailers	44,000	
B	OPERATING AND MAINTENANCE COSTS <sup>1</sup>		
	<sup>2</sup> Hydrogen Peroxide		6,400
	<sup>3</sup> Power		102,200
	<sup>4</sup> Lamp Replacement		9,000
	<sup>5</sup> Operation and Maintenance		<u>61,200</u>
	SUBTOTAL	464,000	178,800
C	ENGINEERING AND CONTINGENCY		
	Design at 20% of Total Capital Cost	92,800	
	Construction Management at 5% of Total Capital Cost	23,200	
	Contingency at 20%	<u>92,800</u>	<u>35,800</u>
	TOTAL	672,800	214,600

PRESENT WORTH

Present Worth Factor (PWF) =	9 427 (30 years, 10% for annual costs)
\$214,600/year x 9 427 =	\$2,022,700
1990 Capital Cost =	<u>672,800</u>
	\$2,695,500

<sup>1</sup> Operating costs based upon a flowrate of 60 gpm, 8 hr/d

<sup>2</sup> \$0 52/lb x 12,200 lb/yr

<sup>3</sup> 500 KW 8 hr/d @ \$0 07/KWh

<sup>4</sup> 2 times/year

<sup>5</sup> 85 hours per month @ \$60/hour

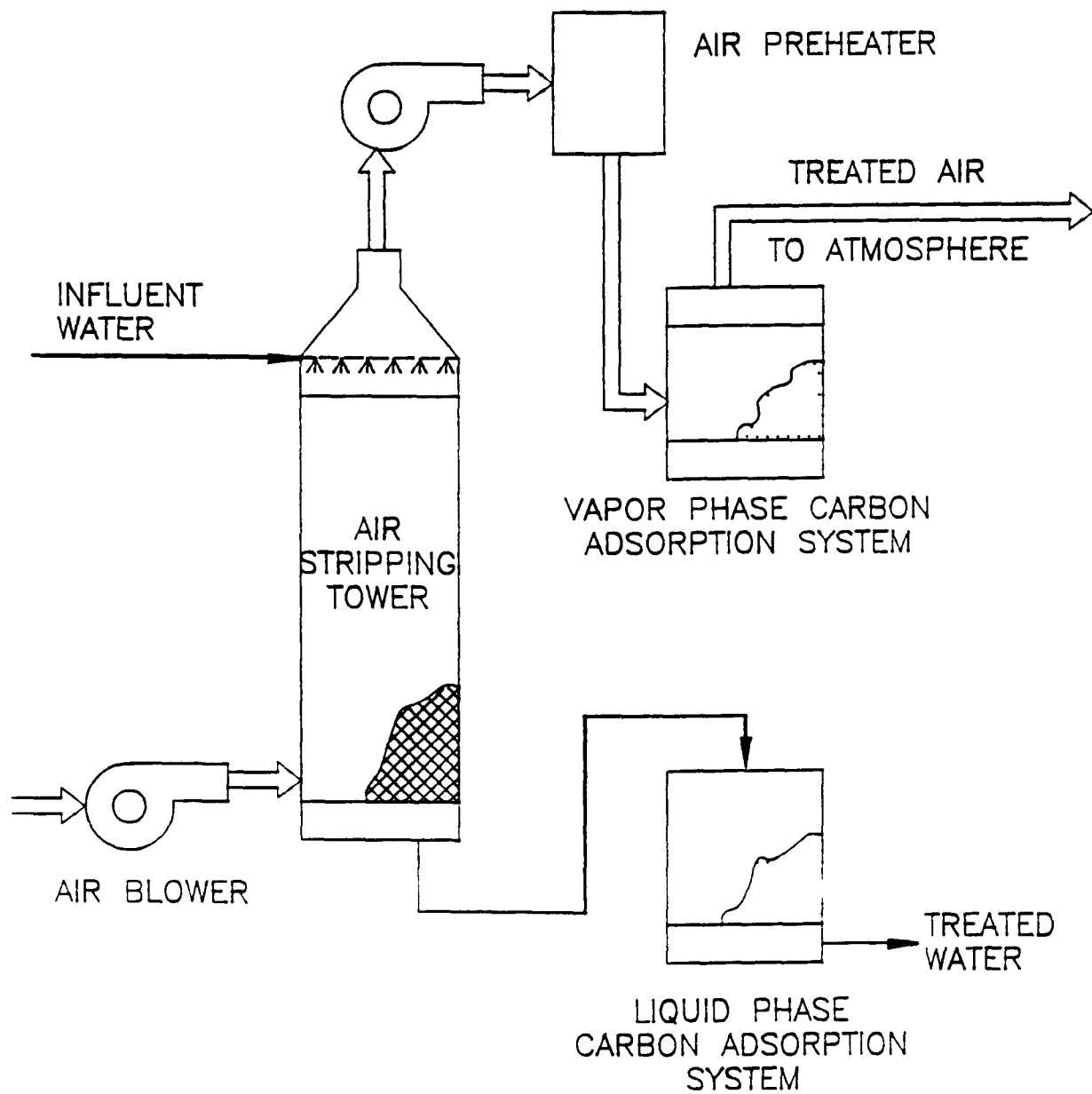


FIGURE 4-9  
AIR STRIPPING WITH VAPOR PHASE  
AND LIQUID PHASE CARBON ADSORPTION

An air stripper coupled with liquid- and vapor-phase carbon adsorption is a proven system that has a dependable record of use. It is expected that this treatment process, with proper maintenance, will provide the desired level of contaminant removal to meet the ARARs.

The system is sized for the intended maximum flow of 60 gpm and includes two vapor-phase carbon units -- one installed and one stock. The on-site stock unit adds to system reliability. All appropriate safety measures required when moving and installing large equipment will be complied with during installation. The operation and maintenance of the system will be performed by personnel properly trained in the handling of hazardous and radioactive wastes. Wet activated carbon preferentially removes oxygen from the air. Therefore, any time personnel are working in confined areas where oxygen may be depleted, appropriate sampling and work procedures for potentially low-oxygen spaces will be followed, including all applicable federal and state requirements.

The operators of the system will not be exposed to VOC-laden carbon from the vapor-phase or liquid-phase carbon units because the use of containerized and transportable carbon contactors allows removal and regeneration/replacement of the exhausted carbon at a remote carbon reactivation site. Carbon will not be handled at the site. Transporting the entire exhausted carbon column itself to the regeneration facility ensures operators are protected from the carbon itself and need only follow routine safety procedures when handling heavy equipment.

The exhausted carbon is generally regenerated through a thermal treatment process which strips the volatile organics from the carbon. The organics are subsequently destroyed via incineration. During this regeneration process, a small quantity of ash may be generated which requires disposal at a landfill. Thus, this process can be considered an alternative to land disposal since the carbon is continuously recycled. However, if the spent liquid-phase carbon is determined to be a mixed waste, then it would require land disposal at a facility permitted to accept mixed wastes. The vapor-phase carbon adsorption system will remove the organics from the air stripper emissions before being released to the environment. Therefore, the vapor-phase carbon adsorption system will eliminate the impact of any air stripper emissions on the public health. The safety of nearby communities should not be adversely affected and the risk of harm to the environment should not be increased. Treated water and air will be monitored to ensure that contaminant levels are below ARARs.

### Implementability

The air stripper will remove greater than 99 percent of the contaminants in the surface water. Because the air stripper performance is sensitive to changes in flow and contaminant concentrations, a liquid-phase carbon adsorption unit is in series with the air stripper to enhance system performance and to ensure that the treated effluent meets ARARs for VOCs. Based on a flow rate of 60 gpm, 24 hours per day, liquid phase carbon usage will be approximately 11 pounds/day, and each 2000-pound carbon unit will require replacement approximately every six months. Vapor phase carbon usage will be approximately 10 pounds/day, and each 2000-pound carbon unit will require replacement approximately every six months.

Operation of the treatment process is relatively simple, requiring occasional cleaning of the air stripping column and replacement of carbon. The air stripper will require cleaning to remove scale buildup on the packing material in order to maintain optimum removal efficiency. Effluent from the cleaning operation will require treatment in the Building 374 Process Waste Treatment System. The removal of suspended solids in a pretreatment step is required to prevent fouling of the carbon and liquid phase adsorber. Transportation and regeneration of the liquid-phase and vapor-phase carbon units at a remote carbon reactivation site will be required. The air stripping with off-gas treatment system for remediating VOC-contaminated surface water is available commercially and could be implemented quickly. No difficulties are anticipated during the installation and startup of this treatment system.

Air stripping with liquid and vapor-phase GAC adsorption should receive a high degree of public acceptance due to its proven track record and classification as a BDAT.

### Costs

Assumed costs for the air stripping ground-water treatment system are shown in Table 4-11. Costs for pretreatment of the influent for removal of suspended solids are not considered in Table 4-11. The total capital

TABLE 4-11

**ASSUMED COSTS FOR AIR STRIPPING WITH  
VAPOR AND LIQUID PHASE GRANULAR ACTIVATED CARBON**

<u>Item</u>		<u>Capital Cost (Dollars)</u>	<u>Annual Cost (Dollars)</u>
<b>A EQUIPMENT</b>			
<u>Quantity</u>	<u>Item</u>		
1	Air Stripper Column	35,000	
2	Trailer	44,000	
1	Preheater	3,000	
<b>B OPERATING AND MAINTENANCE COSTS<sup>1</sup></b>			
	<sup>2</sup> Activated Carbon Service		38,100
	<sup>3</sup> Shipping		15,000
	<sup>4</sup> Power		1,200
	<sup>5</sup> Operation and Maintenance		<u>61,200</u>
	<b>SUBTOTAL</b>	<b>82,000</b>	<b>115,500</b>
<b>C ENGINEERING AND CONTINGENCY</b>			
	Design at 15% of Total Capital Cost	12,300	
	Construction Management at 5% of Total Capital Cost	4,100	
	Contingency at 20%	<u>16,400</u>	<u>23,100</u>
	<b>TOTAL</b>	<b>114,800</b>	<b>138,600</b>

TABLE 4-11 (cont )

ASSUMED COSTS FOR AIR STRIPPING WITH  
VAPOR AND LIQUID PHASE GRANULAR ACTIVATED CARBON

PRESENT WORTH

Present Worth Factor (PWF) =	9 427 (30 years, 10% for annual costs
\$138,600/year x 9 427 =	\$1,306,600
1990 Capital Cost =	<u>114,800</u>
	\$1,421,400

- 1 Operating costs based upon a flowrate of 60 gpm, 8 hr/d
- 2 Activated carbon service costs are based on rental and regeneration of five 2,000-pound columns at \$7,600 per column
- 3 Shipping costs are based on 5 round-trip column shipments per year @ \$3,000 per round-trip shipment
- 4 8 hp, 8 hr/d @ \$0 07/KWh
- 5 85 hours per month @ \$60/hour

cost for the system is \$114,800. Operational costs are approximately \$138,600 and include the cost of carbon column rental and regeneration, and carbon column shipments to and from the vendor. The carbon column rental and regeneration service described in Section 4.4.3.1 will be used for both the liquid and vapor phase units. It should be noted that the cost of the carbon service is based on regeneration of the carbon as a hazardous waste. Assuming a 10 percent interest rate and a 30 year operating life, the present worth of the system is \$1,421,400.

The total present worth cost of the system based on 10 percent simple interest, a 30-year period of operation, and no salvage is estimated to be approximately \$1,421,400. These costs do not include any capital or operating costs for the Building 374 Process Waste Treatment System associated with the treatment of the air stripper cleaning effluent.

## SECTION 5

### COMPARATIVE ANALYSIS

#### 5 1 INTRODUCTION

This section summarizes the screened surface water collection and treatment technologies, and presents a tabular comparison of them (Table 5-1). A recommendation is made for a preferred surface water IM/IRA using the comparative analysis.

#### 5 2 COMPARISON OF TECHNOLOGIES

Collection of surface water by diversion at the sources was established in Section 4 as the only reasonable alternative for collection of contaminated OU 2 surface waters and is, therefore, the preferred collection technique for the IM/IRA. On the other hand, several technologies for surface water treatment were considered. These technologies include cross-flow membrane filtration and granular media filtration with polymer addition for suspended solids removal, cross-flow membrane filtration and ion exchange for radionuclide and metals removal, and GAC, UV/peroxide oxidation and air stripping with liquid and vapor phase GAC for VOC removal.

The cross-flow membrane filtration technology is the preferred method for removal of radionuclides and metals because it is the most likely treatment technology that will remove these constituents from the OU 2 surface water and generate an effluent that is protective of public health and the environment. This is a result of adsorption of radionuclides and metals on a ferric hydroxide floc as described in Section 4.4.2. It is noted that cross-flow membrane filtration and granular media filtration with polymer addition are both effective technologies for removal of suspended solids. However, because cross-flow membrane filtration is the preferred technology for radionuclide and metal removal, additional surface water pretreatment for suspended solids removal is not required. Granular media filtration with polymer addition is thus eliminated from consideration in the IM/IRA. At this time, ion exchange cannot be considered a reliable technology for the removal of plutonium and americium because there is no supporting data on its removal efficiency. Moreover,



TABLE 5-1  
 COMPARATIVE ANALYSIS OF TECHNOLOGIES

<u>Technologies and Assumed Present Worth</u>	<u>Effectiveness</u>	<u>Implementability</u>	<u>Comments</u>
Surface Water Collection			
1 Collection at Sources \$1,284,380	Collection at the source will minimize downgradient contaminant transport which otherwise may contribute to contamination of retention ponds B-5 and C-2  High flow events will transport dilute concentrations of contaminants downgradient	Easily constructed using conventional equipment  Worker and public health and safety must be ensured through monitoring and dust control measures during construction	Effectiveness outweighs difficulties in implementation
Suspended Solids Removal			
1 Cross-Flow Membrane Filtration \$2,833,500	Should reduce TSS to less than 1 mg/l  Proven technology  Likely to meet ARAR for U and evidence suggests ARAR for Pu will also be met	Reliable based on performance at other installations Readily available and skid mounted for easy installation Solids must be removed from backwash water Reasonably simple O&M	Also removes heavy metals and radionuclides
2 Granular Media Filtration \$946,700	Should reduce TSS to less than 1 mg/l  Proven technology	Same as for cross-flow membrane filtration	Less likely to meet ARARs, dissolved radionuclides and metals
Radionuclide and Metals Removal			
1 Cross-Flow Membrane Filtration \$2,833,500	see above	see above	see above

TABLE 5-1 (cont.)

## COMPARATIVE ANALYSIS OF TECHNOLOGIES

Technologies and Assumed Present Worth	Effectiveness	Implementability	Comments
2 Ion Exchange \$717,900	Likely to meet ARAR for U, however, meeting ARAR for Pu is uncertain	Conventional technology, readily available, and easily installed. If regeneration is required, secondary waste generation with increased operational complexity and cost	Upstream suspended solids removal necessary which may remove Pu to achieve ARAR  Will remove heavy metals
Organic Contaminant Removal			
1 Activated Carbon \$1,625,100	Will meet ARARs for organics provided methylene chloride, acetone, and vinyl chloride are not above ARAR	Conventional technology, readily available, and easily installed. Upstream radionuclide removal will allow regeneration of carbon in lieu of disposal as a mixed waste  Effective for variable flow and organic loading	Data suggest vinyl chloride, methylene chloride, and acetone will not be present above ARAR
2 Air Stripping \$1,421,400	Will meet ARARs for organics provided acetone is not above ARAR. Methylene chloride and vinyl chloride, if present, are more readily adsorbed on off-gas carbon than liquid-phase carbon. Will not remove semi-volatiles or highly water soluble organics (acetone, butanone)	Conventional technology, readily available, but installation and operation more complex than liquid-phase activated carbon. Off-gas carbon will be necessary to eliminate transfer of contaminants to the atmosphere. Downstream liquid-phase carbon necessary to achieve compliance with ARARs for organics because of variable organic loading	Operationally more complex than liquid-phase carbon. Data suggest acetone unlikely to be present above ARAR
3 UV/Peroxide \$2,695,500	Should meet ARARs for all identified organics	Readily available off-the-shelf units. Less proven technology than air stripping or activated carbon. Effective operation may be difficult with variable organic loading. More costly than air stripping or activated carbon	Technology of choice for Operable Unit No 1 IM/IRA, however, influent flow and organic concentration should be relatively constant for that application

plutonium and americium will likely be colloidal in nature and less apt to readily exchange with ions on the resin surface. The cross-flow membrane filtration system is also reliable, readily procurable, and easily installed.

GAC is the treatment technology of choice for removal of organic contaminants. GAC is a proven technology that is reliable, easy to operate, and the most cost effective of the three technologies examined. This technology is not suitable for removal of vinyl chloride, methylene chloride, or acetone. However, as discussed in Section 4, these constituents are not expected, in the influent to the treatment system, above their respective ARAR levels. In the event that the field-scale treatability study indicates that vinyl chloride, methylene chloride or acetone are present at concentration levels not appropriate for liquid-phase GAC adsorption, modifications to or replacement of the liquid-phase GAC system will be considered at that time. Although UV/peroxide can oxidize all of these contaminants, effective operation is likely to be difficult with changing organic loadings from a surface water system (i.e., process control). In addition, UV/peroxide is substantially more costly to install and operate than the other organic removal technologies. Air stripping is a viable VOC treatment technology for the OU 2 surface water IM/IRA. This process, however, is much more complex by design than liquid-phase GAC, which makes it more difficult to operate and has a higher probability of system downtime. Finally, the cost of air stripping with liquid and vapor-phase adsorption is roughly equal to that for liquid-phase GAC.

Radionuclides and metals will be removed upstream of the GAC unit. The activated carbon should, therefore, not become a mixed waste and will be suitable for regeneration at any facility that accepts spent carbon for regeneration. This will provide for the ultimate destruction of the contaminants consistent with guidance in the NCP, which requires consideration of remedial alternatives that include an alternative that removes or destroys hazardous substances.

**SECTION 6**  
**PROPOSED IM/IRA**

**6 1     SUMMARY**

The preferred IM/IRA for surface water at OU 2 consists of the following components

- 1        Surface water collection by diversion at the sources, and
- 2        Treatment of surface water by cross-flow membrane filtration followed by liquid-phase, activated carbon treatment

**6 1 1     Surface Water Collection**

Figure 4-2 shows the locations of the surface water diversion and collection systems proposed in this alternative. The collection systems are denoted CS-53, CS-55, CS-59, CS-61, CS-63, and CS-64. Because of anticipated flows and collection system locations relative to the surface water treatment facility, transport of the water from the collection systems to the treatment plant is by tank truck for CS-53, CS-55, CS-63, and CS-64, and by pipeline for CS-59 and CS-61.

Upper South Walnut Creek flow will be collected at the downstream station SW-61 by a new surface water diversion weir and pump station (Figure 4-3). The weir will serve to divert up to 38 gpm (14 gpm average annual withdrawal rate) from the drainage. Contaminated surface water will flow from upstream of the weir through a channel to a 1,000-gallon precast concrete sump provided with a screen, where large debris is separated from the flow. This screen will require manual cleaning to remove debris. Water will be pumped from the manhole to the treatment facility. When the inflow into the sump exceeds the pumping rate, the excess flow will return through overflow piping to the drainage way below the weir.

The seep flow from SW-59 will be isolated from the South Walnut Creek drainage and collected separately from CS-61 using a 1,000-gallon, precast concrete sump. The sump and installed pump will be designed to collect and transfer the design flow of 4.5 gpm (1 gpm average annual withdrawal rate). Flows

in excess of 4.5 gpm will be discharged to South Walnut Creek, via an overflow pipe, to the drainage. The overflow will enter South Walnut Creek upgradient of CS-61 and will either be collected by or allowed to pass CS-61, depending on whether the creek flow is less than or greater than the 38 gpm design flow for CS-61.

The 903 Pad and Lip Area seeps will be collected by CS-55, a newly installed sump at the outlet of SW-55. This collection scheme makes use of the existing surface water diversion pathways and flow described in Section 2.3.5. Installation of a trench connecting SW-77 to SW-55 will allow collection of the flow from SW-77 in the sump. The sump will be precast concrete with a 5000-gallon capacity.

The flow from SW-53 will be collected by a system similar to CS-55. A 5000-gallon capacity concrete sump will be located at the outlet of the existing steel culvert which directs SW-53 flow under the firing range access road.

Surface water seep SW-63 covers a circular area measuring approximately six feet in diameter. A half-circle-shaped trench excavated downslope of the seep will be used to divert seep flow to a sump located at the low point of the trench. The sump will be constructed of concrete and will have a capacity of 5000 gallons.

Surface water seep SW-64 flows into a ditch adjacent to the north side of the site access road. The seep extends approximately 160 feet within the ditch and a high point in the center of the ditch results in water collection on either side of the ditch. A steel culvert buried beneath the access road at the western side of the seep drains the seep water accumulating on this side of the ditch downgradient toward the South Interceptor Ditch. A 5000-gallon concrete sump located at the outlet of the existing culvert is used to collect and store this flow. A second 5000-gallon concrete sump is used to collect the seep water flowing east from the high point in the ditch.

Runon diversion berms will be constructed using clean fill for surface water collection systems CS-53, CS-55, CS-63, and CS-64.

The design flows for the South Walnut Creek (SW-59 and SW-61) and Woman Creek (SW-53, SW-55, SW-63, SW-64, and SW-77) drainages are 42.5 gpm and 9 gpm, respectively. The average annual withdrawal

rates for these drainages are estimated to be approximately 15 gpm and 4 gpm, respectively. It is proposed that all surface waters collected and treated in this IM/IRA will be discharged to South Walnut Creek, just downgradient of SW-61.

#### 6.1.2 Surface Water Treatment

The surface water collected will be treated using cross-flow membrane filtration (for suspended solids and radionuclide removal), followed by liquid-phase activated carbon (for organics removal) (Figure 6-1). The respective units and appurtenances will be housed in three 48-foot trailers to protect weather- or temperature-sensitive components. Fire protection within the trailers will be provided by two wall-mounted, 25-pound, dry chemical-type fire extinguishers. The trailers and all treatment units are constructed of non-combustibles. Other than minimal files and records, no combustible materials will be maintained within the trailers. External water pipes will be above ground and heat traced to protect against freezing. All tanks, piping and sumps will be equipped with secondary containment to comply with 6 CCR 1007-3 and 40 CFR 264.193.

Major components of the treatment system include:

##### Exterior to the Trailers

- (1) 10,000-gallon equalization tank
- piping
- associated pumps, gages, and valves

##### Interior to Trailer 1

- main chemical reaction system
- solids dewatering system

##### Interior to Trailer 2

- filtration system
- process instrumentation system
- neutralization system

### Interior to Trailer 3

- (2) 60-inch carbon units
- (2) 60-inch standby carbon units
- associated plastic (PVC) piping and valves

As the flows from the different sources are expected to vary, the equalization tank will ensure a somewhat constant flow and loading through the treatment system. The treatment system is designed to run continuously at a maximum flow rate of 60 gpm. At peak flow, this tank will provide approximately three hours of equalization detention time. The average annual influent flow rate, however, is estimated at approximately 19 gpm. Surface water collected during periods of these lower influent flow rates will be allowed to accumulate in the equalization tank and then treated at the system design flow rates.

#### 6.1.2.1 Suspended Solids and Radionuclide Removal

When the treatment is initiated, the water will be pumped from the surge tanks to Trailer 1, and subsequently to Trailer 2, which contain all equipment, tanks, pumps, piping, valves, and instrumentation for cross-flow membrane filtration. The system consists of totally integrated, skid-mounted and automatically controlled units for maximum reliability and minimum operator surveillance. The system is divided into various systems as described below.

#### Main Reaction System

Radionuclides and heavy metals will be precipitated and/or adsorbed from solution in the main reaction system. The reaction system will include two 1200-gallon tanks, sized to ensure complete precipitation or adsorption of radionuclides prior to gravity flow to the filtration system. Chemical metering pumps, controlled by pH or Oxidation Reduction Potential (ORP) monitor/controllers, will ensure that optimum reaction conditions are maintained automatically. The tank will be agitated with a heavy duty electric mixer. The equipment provided in the main reaction system will be as follows:

- (2) 1200-gallon, RFP reaction tanks,

- (2) heavy-duty mixer,
- (2) pH monitors/controllers, and
- (2) chemical metering pump(s)

Ferric sulfate will be introduced to the first tank in a liquid solution. However, a system will be provided to dissolve the powdered chemical reagent, for controlled introduction into the main reaction section. In the powdered chemical make-up system, a covered tank will be periodically filled with water, and powdered ferric sulfate will be added manually in a prescribed amount. A mixer will be provided to assure that the reagent is completely dissolved before it is delivered by a metering pump to the main reaction system.

Lime will be added to the second tank as a slurry to raise the pH. The elevated pH will cause precipitation of the iron as ferric hydroxide and create conditions conducive to the adsorption of uranium and plutonium. The lime slurry will be prepared by filling a tank with water and then manually adding a prescribed quantity of lime to the tank through a chute. The mixture will be well agitated with a heavy-duty mixer. The system will be provided with a dust control hood, filter, and fan.

The above peripheral equipment includes

- (2) 250-gallon, heavy-duty plastic tanks,
- (2) heavy-duty, rim-mounted mixers,
- (1) slurry recirculation pump and piping (lime), and
- level control switches and alarms, to be integrated electronically with the main system panel

#### Filtration System

The ferric hydroxide and suspended solids in the reaction section are removed from the water and concentrated in the filtration system.



The main components of the filtration system are

- (1) 3000-gallon, Fiberglass-Reinforced Plastic (FRP) concentration tank,
- (2) 30-HP, 700-GPM recirculation pump,
- (28) cross-flow membrane filtration modules, and
- (1) piped-in-place membrane cleaning system

The concentration tank will be made of fiberglass reinforced epoxy equipped with appropriate baffles and liquid level controls. The recirculation pump will be stainless steel for corrosion resistance and rated at 100 feet of head. The pump will be provided with water-flushed double mechanical seals.

The treated water will be filtered through tubular (1" diameter) filtration membranes made of fluorocarbon polymer, and arranged in trains of 10-tube modules piped in series, supported on accessible horizontal racks. Each module will be 6-feet long and 7-inches in diameter, with a separate outlet for clean effluent. A flow indicating and totalizing meter will be provided on the effluent line. Manifolds will be provided to collect the effluent and direct it by gravity to the neutralization system. The metal/radionuclide suspension will be concentrated to a 2 to 5 percent slurry in the concentration tank, from which it will be periodically pumped to the slurry holding tank and filter press in the slurry dewatering system. The slurry removal rate will be adjusted manually to maintain the desired solids concentration in the filtration section. All piping and valves in contact with the water being treated will be heavy-duty, corrosion-resistant plastic.

#### Neutralization System

A skid-mounted neutralization system will be provided to adjust the effluent pH to the conditions required for discharge or recycle. The neutralization system will be sized to receive and treat the effluent from the membrane filters. The neutralized effluent will leave the system by gravity. The equipment and components of the neutralization system are as follows:

- (1) 1500-gallon, heavy-duty plastic tank,
- (1) heavy-duty rim-mounted mixer,

- (1) metering pump for acid, and
- (1) separate control panel containing
  - 1 pH monitor/controller
  - 1 pH recorder
  - pH out-of-specification alarm
  - electrical switches and contactors

### Process Instrumentation System

A central control panel with a National Equipment Manufacturer's Association (NEMA) 12 rating will be provided to house all controls, electrical switches and disconnects, and motor starters. The main items will include the following

- pH and ORP monitor/controllers/alarms,
- Indicator lights, switches and alarms for major components,
- Motor starters and circuit breakers for all pumps,
- Seal water alarms,
- Level controls and alarms, and
- Effluent flow indicator/totalizer

All wiring and controls will meet applicable national electrical codes

### Solid Dewatering System

The solids dewatering system will include a 4-cubic-foot filter press using an air-operated slurry feed pump to feed concentrated waste slurry from the concentration tank to the filter press. The filter press will dewater the solid to 35 to 50 percent solids. Based on the preliminary sizing, it is expected that the press will be emptied once every five days. The filtrate produced by the filter press will also be directed back to the concentration tank or the feed sump for reprocessing. A dumpster for convenient handling of the dry filter cake, and an air blowdown system for rapid discharge off the filter press will also be included.

### 6 1 2 2 Organic Contaminant Removal

Organic contaminant removal by GAC is a considerably simpler process. After cross-flow membrane filtration, the surface water will be pumped through two GAC columns in series, operated in downflow fixed-bed mode (Figure 6-1). Two additional GAC columns will be in stock. Each carbon column is 60 inches in diameter and 87 inches high and contains 2000 pounds of carbon. Based on a flow rate of 60 gpm, the hydraulic loading to each column will be approximately 3 gpm/ft<sup>2</sup>. Empty bed contact time for each column will be approximately 18 minutes. The columns are of stainless steel construction and will be interconnected by flexible pipe with 2-inch camlock hose connections. Once the column is drained of water, the unit is a shipping container for returning the carbon for regeneration.

### 6 1 2 3 Effluent Discharge

Following treatment, the water will continuously discharge to South Walnut Creek just downgradient of SW-61 and the point of contaminated water collection. Samples will be collected and analyzed twice per week. In the unlikely event that contaminants are present in the effluent at concentrations not protective of public health and the environment, discharge will cease until the treatment problem is identified and corrected. In this event, Ponds B-4 and B-5 will also be sampled and analyzed to assess whether their contents can be discharged (via B-5) in accordance with the Plant's NPDES permit requirements.

## 6 2 OPERATION AND MAINTENANCE

### 6 2 1 Surface Water Collection

The collection systems are relatively maintenance free. Manholes, sumps, and backwater pools will require periodic cleaning to remove accumulated solids. Pumps will also require routine inspection and maintenance.

## 6 2 2 Cross-Flow Membrane Filtration

The cross-flow membrane filtration system's instrumentation and controls will monitor and automatically adjust chemical feed rates. System level switches will automatically operate the feed and process pumps to allow for the continuous flow of surface water through the system. Interlocks and alarms will automatically shut down the system if critical components are operating outside the design limits. Therefore, the system will be capable of processing surface water with only minimal operator attention. However, operator attention required for the system, estimated at less than two hours per shift, will include these tasks:

- 1 Maintaining appropriate solids concentration in the concentration tank by adjusting the amount of waste slurry feed to the dewatering section,
- 2 Replenishing chemicals as needed,
- 3 Routine cleaning and calibration of pH or ORP probes, and
- 4 Periodically initiating the cleaning cycle and changing the cleaning solution. Typically, a cleaning cycle takes less than 1 hour and is carried out once every 40 to 80 hours of system operation.

The filtration system includes a cleaning loop to provide for rapid convenient in-place cleaning of the membrane surface. This includes two 500-gallon polypropylene tanks, an all-plastic cleaning pump (5 HP, 100 gpm at 80 feet of head) and appropriate valves and piping so that the periodic cleaning procedure can be carried out conveniently and quickly. Actual operating experience will determine the cleaning frequency required for optimum performance of the system. During the cleaning procedure, fresh water is used to flush the waste slurry from the modules back to the concentration tank, and a cleaning solution (usually a strong acid) is circulated through the modules with the cleaning pump for a few minutes. Finally, the cleaning solution is flushed from the modules with clean water. Provision is made to reprocess the cleaning solution as part of the normal waste stream, so that only clean effluent leaves the system.

## 6 2 3 Activated Carbon

Operation and maintenance of the activated carbon system is also relatively simple. To completely utilize the carbon, the columns will be arranged in series, allowing the lead column to become fully exhausted.

for subsequent regeneration while the second (polishing) column ensures effluent quality. Periodic samples will be taken from the effluent of each unit, and when the lead unit effluent exceeds chemical-specific ARARs, the lead carbon column will be removed, the polishing (second) column will become the lead column, and a stock carbon column will be put in service as the polishing unit. This is expected to occur every three weeks. The carbon column with the exhausted carbon will then be shipped to an off-site location for regeneration.

### 6.3 ADDITIONAL DOCUMENTS

In addition to this IM/IRA Plan, EG&G will also be preparing the following documents:

- Health and Safety Plan for construction of the IM/IRA,
- Community Relations Plan,
- detailed design plans and specifications,
- detailed "as-built" drawings incorporating all field changes to accurately reflect the constructed surface water collection and treatment system, and
- an Operation and Maintenance Manual for the IM/IRA

### 6.4 TREATABILITY STUDIES

A preferred surface water treatment system for the proposed IM/IRA has been selected in spite of several informational constraints. First, it is uncertain, although unlikely based on the available data, that methylene chloride, vinyl chloride, and acetone are present within OU 2 surface waters. Second, limited treatment technology performance data currently exist for removal of plutonium and americium from natural waters. This is particularly true in the case of ion exchange. Finally, the physical state of plutonium and americium (i.e., dissolved vs. colloidal) in OU 2 surface waters is not completely understood, nor have the radionuclides that contribute to the gross alpha and beta activity been defined. The selected treatment system is the logical choice given the available surface water quality data, literature information regarding plutonium and americium chemistry and treatment processes for their removal, and best engineering judgement.

However, treatability studies are recommended to confirm the selection of the preferred treatment system or to provide the basis for selection of an alternative system should the preferred system be judged to not perform adequately

The DOE will conduct bench- and field-scale treatability studies to determine the effectiveness of cross-flow membrane filtration, granular-activated carbon, ion exchange and other technologies in treating OU 2 surface waters. Objectives of the bench-scale study include optimization of operating parameters, evaluation of performance relative to meeting chemical-specific ARARs and reevaluation of capital and operating costs. GAC will be tested using a mobile field treatment unit which will be deployed in the Mound Area for treatment of surface water from stations SW-59 and SW-61. This water is the most likely OU 2 surface water to contain methylene chloride, vinyl chloride, and acetone, if these analytes are present in OU 2 surface waters at all. The initial operational unit of the mobile field unit is expected to be installed in February 1991 with start up in March 1991. Because this first unit will be used to demonstrate organic contaminant removal efficiencies, it will not be expected to attain chemical-specific ARARs for metals and radionuclides. Additional units will be added over a several month period to evaluate metals and radionuclides removal. A summary report of the treatability study findings will be submitted to the regulatory agencies upon completion of the program. The results of these tests and the bench-scale treatability studies may indicate it is not practicable to attain all ARARs for the surface water IM/IRA. Final performance requirements for the IM/IRA will require approval by the regulatory agencies.

## SECTION 7

### ENVIRONMENTAL EFFECTS OF THE PROPOSED INTERIM REMEDIAL ACTION

The proposed interim remedial action, and potential subsequent environmental and human health effects resulting from this action, are evaluated in this chapter. Environmental impacts to air quality, water quality, terrestrial features (including wildlife and wetlands), archaeology and historic sites, and short- and long-term land productivity are discussed in Sections 7.1, 7.2, 7.3, 7.4 and 7.5, respectively. Human health exposure risks from installation, routine operations, and accidents are analyzed in detail in Sections 7.6 and 7.7. These analyses evaluate the risks to workers involved in the interim action, to other RFP site employees, and to the general public. The commitment of resources (material/human), transportation impacts and cumulative impacts are discussed in Sections 7.8 through 7.10.

#### 7.1 AIR QUALITY

There are three potential air quality impacts associated with the proposed interim remedial action to selectively collect and treat surface water within OU 2 from surface seeps and surface water monitoring stations. These are:

1. Potential volatile organic chemicals released from exposed contaminated liquids during construction activities (i.e., sump installation, trench excavation) or at surface water collection, storage, and treatment locations, as part of normal operations or accident conditions.
2. Fugitive dusts and fossil fuel consumption related exhausts resulting from activities such as excavation, construction, operations, maintenance, and monitoring.
3. Water treatment process off-gassing released to the environment as part of normal operations or accident conditions.

Air quality impacts from VOCs released during construction activities (e.g., excavation) will be minimal when compared to the normal operational activity at the Rocky Flats Plant. The "Phase II RFI/RIFS Workplan" for OU 2 shows VOCs have been detected in the soils at OU 2 and include acetone (up to 480 ppb), TCE (16,000 ppb) and xylene (3,300 ppb) (EG&G, 1990b). Table A-10 in Appendix A presents the test results for VOCs compiled as part of this report. Due to their isolated occurrence, and the limited amount of excavation planned, the amount of VOCs released during this construction activity are not likely to cause measurable

changes in the ambient air quality. Based on sample analyses to date, VOC concentrations in soils at OU 2 are insignificant. Consequently, normal construction activities and excavation for sump installation, buried pipeline/utilities and preparation of the pad area for the treatment system may not release VOCs to the atmosphere. Preliminary characterization, based on the Phase I RI Report, indicates the presence of elevated concentrations of semi-volatile organic chemicals (phthalates) in the soil. Any airborne releases of semi-volatile organic chemicals will be from fugitive dusts associated with construction activities and will be controlled as discussed below.

Dust associated with construction and operational activities will be controlled as specified in the Environmental Restoration's Health and Safety Program Plan (ERHSPP). The ERHSPP addresses the minimum health and safety requirements for outside contractors and is dictated by the ER Department, and Health, Safety Department. The ERHSPP outlines the requirements for a site-specific health and safety plan (SSHSP) that identifies construction task, potential hazards, and the steps to control hazards. The SSHSP must be approved by the ER and HS Departments. Further, the SSHSP will be reviewed by the EPA and the CDH.

Upon approval of the SSHSP, the outside contractor is briefed and assigned an RFP construction engineer. This engineer is responsible for construction management and implementation of the SSHSP by the contractor. The HS Department will then issue a renewable one-week permit, conditional on the workers being briefed and understanding the health and safety concerns of the construction effort. The construction is monitored by the HS Department for contractor adherence to the SSHSP.

In addition to these requirements, the ER Department has developed wind speed and dust control shut-down limits as guidelines for the 881 Hillside Interim Remedial Action. Similar project document guidelines will also be required for construction at OU 2.

Dermal exposure, inhalation, and inadvertent ingestion of airborne radioactivity and VOCs on fugitive dusts is analyzed in Section 7.6, "Personnel Exposure-Routine Operations". Pollution from engine emissions, fugitive dust generation by vehicles and particulates from tire wear are analyzed separately in Section 7.9, "Transportation Impacts".



Collected contaminated surface water will be processed through the proposed cross-flow membrane filtration system and activated carbon system facility. The proposed treatment system will not produce measurable VOC emissions, therefore, no changes in the levels of these gases in the ambient air off site is expected. The need for periodic membrane cleaning will require the use of a small amount of sodium hypochlorite (NaOCl). This could occur once every 2 to 4 weeks and will not impact off-site air quality.

The cross-flow membrane filtration system incorporated into the water treatment system to remove suspended solids, dissolved metals, and radionuclides may not contribute to off-gassing during normal operations or back flushing operations. Mixing of chemicals for water pretreatment or strong acids or bases used for hardware cleaning operations may contribute to odors within the confines of the water treatment trailers and should be controlled by adequate ventilation. These odors will not be noticeable from outside the treatment facility area, nor will they be a hazard to workers in the trailers under normal circumstances. Spills of chemicals that might be involved in accident conditions will be administratively controlled by actions specified in the Operational Safety Analysis (OSA).

The OSA addresses health and safety concerns originating from routine site operations. It is similar to the SSHSP in that health, safety, and environmental hazards are identified and evaluated for control. This analysis is also reviewed by and must be approved by the HS Department. Training is required prior to operation with oversight and monitoring by the HS Department.

Operation and maintenance of the activated carbon system are even less problematic than the cross-flow membrane filtration system. The carbon columns with exhausted carbon will be shipped to an off-site location for regeneration. Spills of liquids associated with the operation of the activated carbon columns will be limited to the effluent exiting the cross-flow membrane filtration system, which will have removed many of the constituents of concern. The effluent water from the membrane filtration treatment system may contain some amount of VOCs. Effluent concentration requirements are contained in Table 4-1, Basis for Design of Surface Water Treatment.

## 7.2 WATER QUALITY

Impacts to water quality arising from the proposed interim action will improve the surface water quality at the RFP. Surface runoff entering excavated areas and exceeding the design capacities of the system may create soil entrainment (sediment transport) by surface runoff ending in open waters on site. The limited amount of water exceeding the design capacity of the system should be minimal.

Some excavation will occur in soils that are expected to have measurable levels of semi-volatile organic chemicals, primarily phthalates. Because phthalates adsorb onto the soil particles and thus are not transferred from soil to water in measurable quantities, surface water runoff should not cause a water quality concern as long as erosion control measures are applied to all soils excavated during remedial action.

Soils surrounding the 903 Drum Storage and 903 Pad Lip sites are contaminated with plutonium and americium (Rockwell International, 1989b). Prior to construction work for the surface water contamination cleanup, surveys will be performed to detect any presence of elevated radioactive contamination. Elevated radioactive contamination will be handled in accordance with the SSHSP procedures.

For the cross-flow membrane filtration system, the greatest potential for negative water quality impacts results from chemicals involved in the pretreatment of the waste stream and concentrated acids or bases utilized periodically for descaling of equipment. Handling of the concentrated cleaning chemicals will be governed by an OSA, as will the precautions for handling the dewatered solids generated in the water treatment process.

Dewatered solids will be handled as a low-level mixed waste. This will require solidification at an existing Rocky Flats Plant facility to meet the transportation and disposal requirements. The solidified waste will be disposed of at the Nevada Test Site or similar facility after it is sampled and analyzed to determine compliance with recently promulgated RCRA land ban restrictions.

The volume of waste will not be a major addition to those wastes already processed at the Rocky Flats Plant. The collection, transport, and treatment of the dewatered solids will be in accordance with standard Plant operating procedures and does not present a significant hazard to on-site or off-site water quality.

The activated carbon adsorption system will provide even less negative impact to water quality on site than the cross-flow membrane filtration system. The carbon columns will be fully self-contained and hold approximately 2,000 pounds of carbon. The units are shipped to an off-site location for regeneration. Approximately one gallon of water per 3 to 4 pounds of carbon (500 gallons) could be spilled during unit changeout of the carbon column. This possibility is mitigated by the use of a secondary recovery system which captures all of the potentially spilled water. The net effect is that there will be no spill during carbon column changeout. Procedures will be established for the safe changeout of the exhausted carbon columns. The transport of the exhausted carbon columns will be in accordance with standard Plant operating procedures and does not present a significant hazard to on-site or off-site water quality.

### 7.3 TERRESTRIAL IMPACTS

Terrestrial environment features that may be negatively impacted by the proposed remedial action include animal life, plant life, and land forms (including wetlands). These negative impacts are expected to be minimal, because of the disturbance to the areas of concern caused by the Plant's construction and operation during the past 37 years. These past disturbances have left the 903 Pad with an asphalt pad cap and the East Trenches Area has surface evidence of burial trenches. The impacts of the IM/IRA will not significantly impact the already-disturbed areas. Numerous species of animal and plant life have been identified at the RFP. No animals are classified as rare or endangered (DOE, 1980).

Rocky Flats flora have been identified through an on-site inventory by Dr. W. A. Weber, et al., (Weber, 1974), from the University of Colorado. The inventory revealed 327 species of vascular plants, 25 lichens, 16 bryophytes, and one macroscopic green algae. None are threatened or endangered.

Excavation for the treatment facility trailers, sumps, and pipelines/utilities will be potentially locally destructive to the vegetation and ground-dwelling rodents, reptiles, and invertebrates. Nests of grassland

songbirds may also be adversely impacted by field activities during the breeding season (March - July) The disturbed area, located to the north of the Mound Area, will be small when compared to the total surface area of OU 2 None of the potentially affected vertebrates, invertebrates, or vegetation in the disturbed areas are threatened or endangered No critical habitats are known in the study area

The proposed interim remedial action will have a minimal or no impact on the water resources management of nearby Woman Creek, South Walnut Creek and the South Interceptor Ditch Currently, the surface water from surface water stations SW-53, SW-55, SW-63, SW-64 and SW-77 are collected by the South Interceptor Ditch, delivered to Pond C-2 for treatment, and piped into the Broomfield diversion canal Surface water from surface water collection station SW-61 feeds into South Walnut Creek None of the surface water collection stations feed or impact Woman Creek

Volumes of water generated from the five southerly surface stations (SW-53, SW-55, SW-63, SW-64 and SW-77) that pass into the South Interceptor Ditch are quite low (see Section 4.3.1) Stations SW-53, SW-63, and SW-77 were observed to have imperceptible flow rates based on April 1990 field measurements and observations A design flow of 0.5 GPM was assigned to each of these seeps A design flow of 3.0 GPM was assigned to SW-55 and 4.5 to SW-64 The cumulative design flow for all five stations is 9.0 GPM, with nominal flow rates expected to be less than one-third this total

The South Interceptor Ditch collects the majority of its water from sources upgradient from the observed sample stations Drainages from neighboring hillsides feed both the South Interceptor Ditch and Woman Creek Several significant water sources upgradient and near the South Interceptor Ditch have been identified outside of OU 2 Historical data observed from the Rocky Flats environmental resources data base showed flows at SW-29 and SW-30 have been measured at 63 and 117 gpm, respectively No meaningful measurements are available to determine the actual flows from the surface water stations in the Woman Creek drainage (and thus the volume of water to be diverted from the South Interceptor Ditch) Based on the design flows from these sources, however, diversion of up to 9.0 gpm should have no impact on water resources management (the average annual withdrawal rate from these sources is estimated to be no greater than 4 gpm) Similarly, the addition of this diverted and treated water from the Woman Creek drainage should have no water resources management impact on South Walnut Creek

Two surface water collection points (SW-61 and SW-103) that feed South Walnut Creek were observed in April 1990. Flows were recorded at 37.3 GPM for SW-61 and at 13 GPM for SW-103. Due to the need for an elaborate drainage system for seep collection, extremely difficult construction, and the potential adverse impacts to wetlands, collection of water from this seep (SW-103) is no longer considered in this IM/IRA. Diversion of water from SW-61, processing the water through the proposed treatment plant (together with the water collected from the southern five collection points), and re-introducing the water just downgradient of SW-61 should have no impact on the water resources management of South Walnut Creek or Woman Creek.

The proposed interim remedial action is not expected to have an adverse effect on linear wetlands. In 1989, EG&G authorized the preparation of a wetlands assessment for the entire Rocky Flats Plant site (EG&G, 1990a). This report identified 107 acres of aerial wetlands and 84,970 feet of linear wetlands within the Rocky Flats Plant site. South Walnut Creek is identified as one of six ephemeral streams traversing the property and is considered relatively important as part of the site drainage system. The proposed action, as it impacts wetlands, will not be discernible from current stream management.

As observed in the prior discussion on water resource management, diversion of up to 9.0 GPM from the South Interceptor Ditch and Pond C-2 will have no noticeable impact. The wetland south of the 881 Building and extending to the C-2 Pond (approximately 0.15 acres) should not be impacted due to the low volume of water generated by the surface water collection stations in the area.

Similarly, no wetlands impact is expected from treating water prior to reintroduction into South Walnut Creek. The proposed action calls for withdrawal of up to 38 gpm of contaminated surface water from station SW-61 and 4.5 gpm from SW-59. Water from these collection points will be diverted into 1000-gallon capacity sumps and piped to the 60 gpm treatment plant to provide the treatment plant with a constant feedstock. Water from the treatment plant will be reintroduced into South Walnut Creek near the point of greatest potential withdrawal (SW-61). Diversion of up to 42.5 gpm should continue for no more than 48 hours before the clean water is reintroduced. Any loss of water due to evaporation or treatment should be made up from the small contribution entering South Walnut Creek, which originates from the South Interceptor Ditch.

As mentioned earlier, treated water from the treatment system will be discharged into South Walnut Creek, just downgradient of CS-61 (the surface water collection system of SW-61). The South Walnut Creek basin contains a series of five on-channel reservoirs. The last pond in the series, Pond B-5, discharges directly into South Walnut Creek. Water volume is managed by these ponds and is discharged directly to South Walnut Creek in accordance with the Plant's NPDES Permit. Discharged water follows the South Walnut Creek drainage north to the natural Walnut Creek drainage. Surface water flow in Walnut Creek near the property boundary is currently being diverted around Great Western Reservoir, which is a drinking water source for the City of Broomfield, and is then returned to the natural drainage channel. Due to the ephemeral nature of South Walnut Creek, no impact to wetlands is anticipated as a result of the proposed action to treat surface water.

Although no long-term impact to wetlands is anticipated, it is possible that construction activities could adversely affect a few wetlands plants during ditch modifications or sump installation. Replacement of any destroyed wetland plants will follow the completion of construction, resulting in no net impact to wetlands at the RFP.

#### 7.4 ARCHAEOLOGY AND HISTORIC SITES

The 903 Pad, Mound and East Trenches Areas have been highly disturbed over a number of years. Due to this disturbance and the topographic position of the subject area, the State Office of Archaeology and Historic Preservation has determined that this action will not impact cultural resources (Burney, 1989).

An archaeological and historical survey of the RFP was conducted between July 18 and August 22, 1988, which determined two sites have potential eligibility to the National Register of Historic Places. However, insufficient information currently exists to make this determination. These two sites are located northwest and southwest of the investigation area, and will not be disturbed by the proposed action (Burney, 1989).

## **7.5 SHORT- AND LONG-TERM LAND PRODUCTIVITY**

Land within OU 2 is currently undeveloped and will remain so for the foreseeable future as part of the Rocky Flats Plant. OU 2 lies within the Rocky Flats Plant security boundaries and is not accessible to the general public.

## **7.6 PERSONNEL EXPOSURES - ROUTINE OPERATIONS**

The effects of personnel exposures to hazardous chemicals have been estimated in terms of increased risks of either developing cancer (carcinogenic risk) or some other adverse health effect due to the exposure (noncarcinogenic risk). Analyses were done separately for those directly involved in remedial actions (workers), other RFP personnel not directly involved in remedial actions (site employees), and off-site individuals (general public).

Airborne contaminant concentrations at the receptor (site employees, general public) locations were estimated using the Gaussian Plume Equation of Pasquill as modified by Gifford (1961) for ground-level concentrations at the centerline of the plume, as defined in the Plan for Prevention of Contaminant Dispersion (PPCD).

The average dispersion is a function of the downwind distance, whether the contaminant emission is a long-term (construction, operation) or a short-term (accident) source, and the prevailing meteorological conditions.

The toxicity assessment (intake and risk) for carcinogenic and noncarcinogenic effects of chemicals was performed in accordance with the EPA's Risk Assessment Guidance for Superfund Sites (EPA, 1989a). EPA's Integrated Risk Information System (IRIS) was utilized as the primary source for toxicity information (RFDs and slope factors). EPA's Health Effects Assessment Summary Tables for the fourth quarter of FY 1989 (EPA, 1989b) were used as a secondary source of information. For organic chemicals, inhalation toxicity values (RFDs, slope factors) were estimated using the oral pathway values in those instances where inhalation values

were not available. It would be expected that the toxicity values for both pathways would be similar due to similar absorption efficiencies for organic materials.

Estimates of carcinogenic risks were calculated for each of the organic chemicals identified in Table 4-1, and the individual risks summed for a total carcinogenic risk. The carcinogenic risks are considered to be cumulative for the entire period of exposure and the calculations yield an estimate for the lifetime increased risk of cancer.

Noncarcinogenic risks are considered "threshold" events. That is, no effect is observed below a given exposure. The potential for increased health effects are expressed in terms of the noncancer hazard quotient, which equals the exposure level divided by the reference dose (noncarcinogenic toxicity value). The EPA methodology assumes that a quotient value of less than one is unlikely to result in adverse health effects, even for sensitive population groups. Generally, the greater the quotient value above unity, the greater the level of concern. Chronic or subchronic reference dose values were utilized in the noncancer hazard quotient calculation, depending on the potential duration of the exposure.

Exposures to site employees and members of the general public were analyzed based on a single, hypothetical individual for each exposure category. Site employees were assumed to be assigned, eight hours a day for the duration of the release, to whatever building would receive the greatest average airborne exposure. For the proposed action, the nearest occupied locations resulting in the greatest exposure to other site personnel include Building 991 and the Gate 9 guard post (inner guard post on east access road). The analysis of the impact to the general public assumed a single individual would remain at the point of highest exposure (due east at Plant boundary) accessible to the general public for each pathway, twenty-four hours per day, for the entire duration of the release. These calculations provide an upper bound for the increased risks to an individual from each of these groups. During the remedial action, it is unlikely that any worker, site employee, or member of the general public would exceed or even approach the risks estimated for their respective group.

In calculations of the estimated increased risks to members of the general public from hazardous chemicals, the impacts on infants and young children were calculated separately from those on adult members.



of the population. Infants and young children differ from adults in the rate of uptake of the hazardous chemicals and in body weight. Both of these factors influence the calculations of increased risk. To assess noncarcinogenic risks, noncancer hazard quotients were estimated for both children and adults. The numbers quoted in the text of this document are those for the group with the greatest increased risk or concern. Carcinogenic risks to a member of the general public were estimated assuming exposure for the entire length of the release, which was conservatively assumed to be thirty years. Two exposure categories were considered: 1) the member of the public is already an adult when the project starts, and 2) the individual is assumed to be a child for the first five years of remedial action and an adult for the remaining 25 years. The numbers in the report represent whichever analysis yielded the highest increased risk of cancer.

The intake of radioactive materials has been assessed by calculating total intake by individuals and converting that to Committed Effective Dose Equivalent (CEDE) using the exposure-to-dose conversion factors for inhalation (Table 2.1 of EPA, 1988) Internal Dose Conversion Factors for Calculation of Dose to the Public, Part 2 (DOE, 1988b), was used to assess dose to the public. The calculated exposure values are then compared with the applicable DOE limits for each receptor group. DOE Order 5480.11 (DOE, 1988d) establishes a limit of 5 rem (effective dose equivalent) per year for occupational workers. DOE Order 5400.5 (DOE, 1990b) incorporates a Clean Air Act (CAA) limit of 10 mrem (effective dose equivalent) per year for members of the public from routine airborne emissions and a dose limit of 100 mrem (effective dose equivalent) per year from all exposure modes.

#### 7.6.1 Worker Exposure Risks

Workers involved in the installation of collection facilities and those involved in operation of the facilities associated with the remedial action may experience increased risks through several pathways:

1. Airborne exposure to VOCs near construction activities, equipment installation, or within the facility.
2. Dermal exposure to organic and inorganic chemicals or radioactive materials, especially during construction activities.
3. Inhalation of organic chemicals, inorganic chemicals, or radioactive materials on fugitive dust, especially those generated during construction activities.

## Airborne Exposures to VOCs

It is proposed that the treatment facility be located near the north boundary of the Mound Area. Associated piping and utilities will be located outside all existing IHSSs to avoid, to the degree possible, soil contaminated with VOCs. There will be monitoring to assess possible exposures to VOCs during these construction activities. Protective measures appropriate for the level of VOCs detected will be specified in the SSHSP to protect the workers. The potential for chronic or routine exposure of workers to VOCs resulting from operations and maintenance tasks will be small. OSA procedures will be established to control potential hazards to workers.

The treatment facility trailers will be ventilated to prevent the buildup of VOC vapors in the work environment. The process reaction, concentration, and neutralization tanks will be equipped with hinged covers to minimize the introduction of VOC vapors into the work area. The filtration, dewatering, and carbon adsorption units are closed systems and thus will not act as VOC vapor sources. Periodic (every 1 to 3 days) removal of dewatered solids (sludge) from the dewatering equipment will be necessary. This will require opening of the filter press housing and potential short-term exposure to VOC vapors. Facility ventilation and OSA procedures will provide appropriate personnel protection. The wet consistency of the sludge will preclude potential aerosolization of radioactive particulates and associated exposure from inhalation. The dewatered solids will be handled as a low-level mixed waste. Outdoor operational tasks, such as transport of contaminated water from selected collection systems (CS-53, CS-55, CS-63, and CS-64) to the treatment facility, will be performed in accordance with the appropriate OSA.

Activities that might lead to nonroutine exposures, such as opening tanks or other maintenance operations, will be of short duration and will not lead to chronic exposures. Monitoring these activities will be necessary, however, to determine that adequate protective measures were used to assure that workers were not exposed to VOC levels exceeding appropriate limits for the individual chemicals.

## Dermal Exposures

As with airborne exposures, potential dermal exposures will be controlled with the implementation of SSHSP and OSA procedures. Potential levels of protection from splashing and contact with contaminants include the use of gloves, protective clothing, goggles, and hoods.

During construction activities for the proposed action, there will be little or no potential for dermal contact with soil contaminated with VOCs. The treatment facility will be constructed near the north boundary of the Mound Area, where VOC contamination levels are anticipated to be low. The piping for the water treatment facility will be routed through uncontaminated soil. Excavation for the collection stations, except for SW-61, are not expected to involve removal of damp soil which may be contaminated by VOCs. Any excavated damp soil will be treated as a RCRA mixed waste until determined otherwise. Inorganic chemicals and radioactive materials identified in the work areas are not readily absorbed through the skin and would result in a negligible exposure pathway.

Personal protective measures may be necessary during some routine operations activities where there is a potential for contact with contaminated water (e.g., routine water sampling or solids removal in the treatment facility). If such measures are necessary for the protection of the workers, they will be specified in the OSA for those activities.

## Inhalation of Fugitive Dust

Fugitive dusts are likely to be generated during construction activities or during operation of the water collection and treatment facilities. The Phase II Sampling Plan (EG&G, 1990) includes soil sampling in the areas of interest, but the results are not yet available. For this reason, the surface soil conditions have been estimated using available soil samples from the Phase I RI/FS (Rockwell, 1987a). Where soil samples were not available, the nearest soil samples located between the area of interest and the most likely source of contamination have been used.

The soil samples indicate that the only organic chemical found in soil above the water table is bis-(2-ethylhexyl)phthalate. Consequently, it is the only significant organic chemical contributing to carcinogenic and noncarcinogenic effects from the fugitive dust pathway. Radioactive contaminants of concern from the fugitive dust pathway include plutonium and americium. The estimated level of plutonium in the surface soils for collection systems CS-63 and CS-64 was taken from the 1988 Annual Environmental Monitoring Report (Rockwell, 1988c). Plutonium levels in the surface soils for collection systems CS-53, CS-55, and CS-61 are based on data from the nearest available boreholes. These boreholes are located within the 903 Pad Lip area where the contamination levels are expected to be much higher than at the location of the collection systems. In soil samples where both americium and plutonium were reported, the americium contamination levels averaged 13.5 percent of the levels of plutonium contamination. In these calculations, it is assumed that americium is equal to 15 percent of the reported plutonium contamination level.

Dust control measures will be specified in the SSHSP to limit inhalation exposures to workers involved in construction activities. These measures will be derived from the PPCD. Even if workers were to be exposed to the maximum dust loading permitted by OSHA regulations for nuisance dust during the entire period of construction activities, the effects of either fugitive radioactive material or phthalates would be insignificant.

Transfer of contaminated surface water by tanker truck results in a fugitive dust source term during operations. While the fugitive dust generated in the wake of the vehicle may provide an exposure pathway for other site workers and the public, it is not expected to be a significant exposure pathway for the vehicle operator. The treatment facility and surface water collection sites will not normally be occupied by site personnel. Consequently, there will be no significant exposure of site personnel to fugitive dusts at these locations.

#### 7.6.2 Site Employee Exposure Risks

Other workers at the RFP site could be exposed to low levels of VOC vapors released during normal operation and to fugitive dust generated both during installation and operation of the facilities associated with the proposed action.

Although the vent on the feed equalization tank (see Figure 6-1) on the water treatment facility will have an activated charcoal filter attached in order to estimate an upper bound to personnel exposure, a calculation was performed to determine the potential VOC releases from the vent without a filter attached. Since that tank is the largest single tank in which untreated water is collected, it was chosen as the tank which, if unfiltered, could lead to the greatest exposures to other site employees or the public. Any other tanks, sumps, or pump vents would lead to lower exposures and lower risks. In the calculation, it was assumed that the liquid in the tank was at the contamination levels listed in Table 4-1 and that the vapor in the tanks had reached equilibrium with the liquids. It was further assumed that the vapors are displaced by in-flowing liquids at an average rate of 60 GPM, the design processing rate. That is, it is assumed that the average liquid inflow must equal the processing flowrate, but no credit was taken for water being removed from the tank. Under these circumstances, the maximum total cancer risk and total new cancer hazard quotient would be low.

There will be dust generated during the construction of the water collection facilities as well as the water treatment facility. Although dust suppression measures will be implemented in accordance with the PPCD and SSHSP, the following conservative analysis, which assumes no dust suppression measures and high estimates of areal disturbance and construction time, has been used to estimate health risks from dust generation. The dust generation rate was estimated using the construction generation rate of 1.2 tons per acre per month (average soil moisture conditions) from AP-42 (EPA, 1985). AP-42 is an EPA document for estimating source terms for air pollutant emissions. It was assumed that the project would create dust over an average area of one acre for two months. This multiplication led to a calculated average generation rate of  $4.2 \times 10^{-4}$  kg of dust per second. To be conservative in calculating the exposure of site employees, it was assumed that all the dust was generated at the water treatment facility site since that would produce the maximum exposure to the personnel at the inner east guard post (located at the intersection of East Road and the Northeast Access Road). The approach utilized to estimate surface contamination levels contributing to fugitive dust has been discussed in the fugitive dust portion of Section 7.6.1 of this report. Using a wind direction weighted dispersion factor ( $x/Q$ ) from the water treatment facility to the guard post of  $8.46 \times 10^{-5}$  seconds per cubic meter, it is estimated that an individual assigned to that guard post for the full sixty-day duration of the construction activities would receive a maximum dose of 1 mrem CEDE from radioactive materials in the fugitive dust. The corresponding incremental cancer risk and noncancer hazard quotient due to the presence of phthalates in the dust were calculated to equal  $1 \times 10^{-13}$  and  $4 \times 10^{-10}$ , respectively.

Unlike the construction activities that are of limited duration, operational activities that might generate respirable dust would continue for the lifetime of the interim action. It is currently proposed that surface water from the Woman Creek seeps be trucked to the treatment site. However, pre-design engineering analysis will determine the appropriateness of piped versus trucked transport. The following analysis represents the worst-case scenario of trucking surface water for treatment. In this extreme case, the principal source of dust would be the transportation of the water collected at collection sites CS-53, CS-55, CS-63, and CS-64 to the treatment facility. The closest continuously occupied building is the guard post. The value of  $x/Q$  is different, however, because both the distance to the area where the dust is generated and the wind direction to carry it to the guard post are not the same as during construction activities. The calculated average value for  $x/Q$  for this exposure case is  $1.58 \times 10^{-5}$  seconds per cubic meter. The dust emission rate was calculated using the equation for fugitive dust from travel on unpaved roads from AP-42. It was assumed that transport would be by a thirty-ton tanker truck traveling at an average speed of twenty miles per hour on gravel roads for an average of fifty miles per week, fifty-two weeks per year. The same soil concentration was used as described in Section 7.6.1 of this report. Under these circumstances, it was calculated that the dose to someone assigned to the guard post eight hours a day for the full year would receive a maximum dose of less than 1 mrem CEDE from the radioactive material in fugitive dust. As noted above, fugitive dust may also contain phthalates, resulting in an incremental cancer risk to the same individual assigned to the guard post of  $2 \times 10^{-12}$  and a noncancer hazard quotient of  $9 \times 10^{-10}$ .

### 7.6.3 Risks to Members of the Public<sup>1</sup>

Members of the public could be exposed to the same sources of risk as described in the previous section for other RFP site workers. The airborne concentration of the fugitive dust would be less for members of the public because of the greater dispersion distance from the source.

---

<sup>1</sup> Throughout this report, the term "general public" has a special and very restricted meaning. In order to estimate the maximum exposure or risk to any individual outside of the RFP site, all estimates are based on exposure to a person at the site boundary location having the highest average airborne concentration who remains there for 24 hours each day, 365 days each year, for the duration of the operation or the remedial action.

The public may be exposed to fugitive dust containing phthalates, plutonium and americium generated during both the construction and operation phases of this action. Doses to the public were analyzed for two sources of dust as discussed in Section 7.6.2 above. The maximum dose to a member of the general public from radioactive contaminants present in dust generated during construction activities would be about 0.02 mrem CEDE. The doses from dust generated during vehicular travel for water collection (should this option be used) would add approximately  $5 \times 10^{-2}$  mrem per year CEDE. These are both very low and are well within airborne exposure limits of 10 mrem per year to any member of the general public (DOE, 1990). The maximum incremental cancer risk to a member of the public due to phthalate contamination within the dust was calculated to be negligible during both construction and normal operation (liquid transfer truck activities), with values of  $5 \times 10^{-15}$  and  $1 \times 10^{-13}$ , respectively. The corresponding noncancer hazard quotient was calculated to equal  $1 \times 10^{-9}$  for construction activities and  $3 \times 10^{-9}$  for normal operation.

As discussed in section 7.6.2, potential VOC releases from the feed equalization tank were analyzed to provide an upper bound on the risks from releases from other, unfiltered tanks. Using the same assumptions as described in section 7.6.2, the maximum cancer risk and non-cancer hazard quotient for a member of the public would be low.

From the above, the cumulative maximum cancer risk to a member of the public during the operational phase of the proposed action is  $7 \times 10^{-11}$  and is dominated by potential VOC releases from process equipment and tanks. The cumulative noncancer hazard quotient for the operational phase is approximately  $1 \times 10^{-7}$ .

## 7.7 PERSONNEL EXPOSURE - ACCIDENT

Any accidents that may occur during the construction phase of the proposed action are those typical of small excavation or construction activities. The SSHSP will identify appropriate precautions and responsibilities for each job. Workers will be familiar with the SSHSP and a copy of it will be available at the work site. No credible accident during construction would lead to exposure of either workers, site employees, or members of the public to levels greater than those resulting from the severe accident case analyzed below.

During operation, accidents that could impact either workers or members of the public would include fires or major spills of contaminated material. Spills of untreated water within the treatment facility would create the potential for short duration airborne VOCs. Uptake of contaminants by workers involved in the cleanup would be controlled by following safety precautions specified in the OSA. Any airborne VOC releases through ventilation systems that could lead to exposures of other RFP employees (site employees) or the general public would be less than the tank rupture discussed later in this section.

The initiation and propagation of fire within the treatment facility is a credible accident. The facility trailers are equipped with chemical fire extinguishers, however, the trailers will not normally be occupied. Any VOC releases would be bounded by the severe accident case since concentrated VOCs would be contained within the activated charcoal columns which are closed components and filled with water. Solids which are in the filter press housing or which have been removed and placed in metal containers constitute a potential radioactive material source term. A fire would have to both dry out and aerosolize the solids as well as breach the metal containment to result in a radioactive release. Since the solids are inorganic and in a sludge form containing 60 to 70 percent water and are within metal containers, and the trailer is the only major combustible material present, it is concluded that the fire duration and intensity would be insufficient to result in a radioactive material release resulting in any significant impacts.

Based on the maximum amount of contaminants potentially available for release and the dispersible form of the contaminants, the most severe credible accident with potential for the exposure of either site employees or the public would be airborne VOCs released with the rupture of the 10,000-gallon water collection tank. Transfer of contaminated water or filter press solids (sludge) by truck will not pose as great an accident concern for several additional reasons. These transportation activities will occur exclusively on site, in accordance with the On-Site Transportation Manual, and will not involve any public roads. Consequently, transportation speeds and distances will be low, minimizing the likelihood of severe accidents and any attendant contaminant releases. Also, site emergency response capabilities will be readily available to control any accident spills or container failures. Other transportation impacts are discussed in Section 7.9.

The analysis of the severe accident assumed the tank to be full of water at the design basis concentrations shown in Table 4-1. It was further assumed that all the contents are spilled and all VOCs off-



gas completely within the first twenty-four hours following the spill. The analysis indicates the total increase in cancer risk to the maximally exposed member of the public would be  $1 \times 10^{-10}$ . The corresponding noncancer hazard quotient would be very low, with a value of  $3 \times 10^{-6}$ . For other site workers, the cancer risk would be about  $3 \times 10^{-9}$  and the noncancer hazard quotient would be  $6 \times 10^{-5}$ . Both of these values are negligible and would result only if no efforts were made to protect the workers downwind of the spill.

If any workers were present during an accident involving the rupture of the inlet tank, the danger of traumatic injury would be a greater concern than intake of hazardous chemicals or radioactivity. The radioactive materials present in the water are not volatile, nor are they readily absorbed through the skin, so they do not present an ingestion hazard to the workers at the scene of the incident. The organic chemicals would not volatilize immediately. Thus, while the airborne concentration levels near the tank would be higher than off-site or other on-site locations, the workers would be aware of the incident and would either evacuate or take protective actions, thus limiting their total exposure to the hazardous material.

## 7.8 COMMITMENT OF RESOURCES

The scope of the proposed interim remedial action is small and the resources (material/human) for construction and operation of this surface water treatment system will likewise be small. No significant commitments of valuable resources are involved.

With the exception of the land area, all of the materials for construction and operation of the water treatment system will be irrevocably and irretrievably committed to the implementation of the remedial action. Most of these resources are normally consumed at the Plant at a rate which makes the requirements of the remedial action insignificant. The water pretreatment chemicals and cleaning solutions are already in use at the RFP. The chemicals for the cross-flow membrane treatment system and the carbon canisters are all readily available from off-site sources. The anticipated use of process chemicals, cleaning agents, and carbon will all be available within the Denver metropolitan area.

## 7 9 TRANSPORTATION IMPACTS

Human health impacts normally incident to transportation include vehicle emissions in addition to possible traumatic injuries and fatalities resulting from vehicular operations. Normal transportation for the proposed action consists primarily of a single water truck (5,000-gallon capacity) collecting water from specific sources on a scheduled basis. Total mileage is expected to average less than 50 miles per week. In addition, a slight increase in emissions might result from pumping actions associated with on-loading and/or off-loading the water truck.

Normal transportation produces engine emissions, fugitive dust generated by vehicular traffic on unpaved surfaces, and particulate from tire wear. The table below presents an estimate of emission rates for the operation of a typical water truck.

### WATER TRUCK EMISSIONS RATE

<u>Pollutant</u>	<u>Emission Rate (lbs/100 gal. fuel)</u>
Hydrocarbons	13.1
NO <sub>x</sub>	286.0
SO <sub>x</sub>	31.2
CO	123.5
TSP	17.7

The impacts on health resulting from transportation during the proposed action includes the potential for both pollution- and accident-related impacts. The table below presents estimates of risks resulting from truck transportation (Rao, 1982).

### HEALTH EFFECTS PER KILOMETER

<u>Source</u>	<u>Mode</u>	<u>* LCFs</u>	<u>Injuries</u>	<u>Fatalities</u>
Pollutants	Truck	1.0 E-7		
Accidents	Truck		5.1 E-7	3.0 E-8

\* LCF = Latent Cancer Fatality

Uncertainties are associated with pollution emission rates and atmospheric dispersion behavior. To compensate for these uncertainties, the analysis used conservative estimates for determining pollution health effects. The tabulated accident impacts are average values over all population zones (urban, suburban, rural) and are derived from nationwide Department of Transportation (DOT) statistics.

The proposed action will involve transportation activities during the construction phase as well as during subsequent operations. All construction shipments are anticipated to be made mostly by truck and will originate within the Denver metropolitan area (within a 50-mile radius of the Plant site). Materials to be brought on site include the treatment systems, storage tanks, piping, concrete, and associated equipment. The delivery of these materials will require several truckloads over the construction period, followed by routine transport travel between collection areas and the treatment facilities (estimated at less than 50 miles per week). The resulting transportation impacts will be small as seen from the tabulated emissions and health effects estimates. To place transportation impacts to the general public in perspective, it is observed that approximately 60,000 round-trip truck shipments (one-way distance of 50 miles) would be required to result in one additional latent cancer fatality (LCF). An average of 210,000 truck shipments would be required to result in one additional traumatic fatality. The increase in site travel during construction may be noticeable but will be of short duration. Outside the Plant boundary, the increase will not be noticeable.

Treatment of contaminated surface water from the OU 2 will result in an incremental increase in site pickup and deliveries of spent carbon columns and replacement units and chemicals for the pretreatment of water for the cross-flow membrane treatment system. Deliveries will be spread out over the course of the year and will be handled by one of the existing Plant chemical suppliers. The very small number of shipments involved for both the carbon columns and the cross-flow membrane treatment system will result in an insignificant impact to human health.

Off-site transportation impacts associated with the shipment of solidified filter sludge to a mixed waste disposal site, such as the Nevada Test Site, will be very low as determined in DOE (1990b). Relatively low concentrations of contaminants, the physical form of the waste, disposal site waste acceptance criteria, and compliance with DOT packaging and transport requirements all contribute to very low health effects from incident-free shipment and accident events.

Operational activities will also include periodic inspection of the collection system to remove debris or other obstacles, as well as routine inspection of the pipeline system providing direct feed to the water treatment facility. This will require vehicular travel to each source area, which is estimated to total 20 to 30 miles per week. Impact to human health (latent cancer fatalities from vehicular pollution) will be negligible.

## 7.10 CUMULATIVE IMPACTS

Routine processing of the surface water gathered from the surface seeps and drainages will result in some additional solid wastes being generated from the site. With a peak flow estimated to be approximately 75 cubic feet per week, the semisolids from the cross-flow treatment system will be treated on site and shipped to the Nevada Test Site or similar facility for final disposal. The annual production rate of the semisolid will average much lower. All gaseous releases will be undetectable off site. None of the materials that may be released are expected to be concentrated by any natural process.

The drying of the semisolid sludge waste from the treatment system will require an increase in Plant solidification operations to dry and package the waste for transport to a final disposal site. Neither the drying nor packaging requirement will add significantly compared to the current workload of the facility. Radionuclide accumulation in the sludge is not expected to exceed exempt quantities by weight, so that shipment of the sludge is not expected to cause any special concern or require unusual controls.

It is estimated that four workers will be involved in routine operation and maintenance of the surface water collection treatment facility. This will have negligible impact on the workload of Plant personnel. In routine operations, these workers will not be exposed to any levels of chemicals or waste stream pollutants that would restrict them from other assignments at the RFP.

Construction activities will result in increased vehicular traffic, engine emissions, and the number of workers. The number of personnel required for the proposed action will be a small increase to the assumed yearly additional construction loading.

Discharges of treated water into the South Walnut Creek basin near its point of withdrawal may total up to 600,000 gallons per week during peak flow. After surface water loss due to percolation and evaporation, additional discharges may be necessary from the B-5 pond. These discharges, in addition to the current NPDES discharges, are not expected to impact Walnut Creek downstream of the B-5 pond.

## SECTION 8

### ENVIRONMENTAL EFFECTS OF THE ALTERNATIVES

The preferred alternative and the proposed action for this interim remedial action is to gather contaminated surface water from a series of point sources, transfer the collected water via pipeline and/or truck, and process the water through a water treatment system. The preferred treatment system consists of a cross-flow membrane treatment system for removal of radionuclides and metals, followed by a carbon column system for removal of VOCs. The treated water will then be returned to South Walnut Creek.

Several alternatives to the proposed IM/IRA were evaluated for environmental effects. The alternatives included 1) no action, 2) surface water collection at Ponds B-5 and C-2, and 3) ion exchange, granular media filtration with polymer addition, UV peroxide oxidation, and air stripping. The alternative of surface water collection at Ponds B-5 and C-2 has been eliminated based on the potential of generation of additional contamination and additional volumes of water requiring treatment (See Section 4-1). Each remaining alternative is evaluated in regard to environmental quality, personnel exposure and transportation impacts. Following the alternative evaluation, Table 8-1 compares the potential impact of the proposed action with the alternatives.

#### 8.1 ENVIRONMENTAL EFFECTS OF NO ACTION

Although the no action alternative is in direct conflict with the agreement in principle reached among DOE, EPA, and the State of Colorado, it is discussed herein.

##### 8.1.1 Environmental Quality

The No Action alternative would not involve any short-term impact to the environment or the workforce/general population and would eliminate the need for off-site transportation activities. However, it would not contain nor remove any radionuclides, VOCs or inorganic contaminants. The No Action alternative would pose a long-term release risk to the general public and would require remedial actions in the future.

The No Action alternative would require that the current quarterly site monitoring be continued. Because the monitoring is a part of the existing plant environmental monitoring program, the impact on plant operations and the surrounding community would be effectively zero. However, because off-site migration may occur in the future, the No Action alternative is unacceptable.

#### 8.1.2 Personnel Exposure

The No Action alternative will have minimal impact on current workers at the site or at adjacent sites. Workers would still be required to collect quarterly sampling, which would present no additional impact above current impact levels. The sources of hazardous materials would neither be removed nor controlled. However, the possibility of releasing contaminated water off-site would increase over time. The site would then be a source of public exposure in the long term.

#### 8.1.3 Transportation

Since no remedial action would occur under this alternative, there would be no on-site or off-site transportation activities associated with this alternative or related impacts to workers or the general public.

### 8.2 ENVIRONMENTAL EFFECTS OF ALTERNATIVE 2

#### 8.2.1 Environmental Quality

A variety of treatment technologies were investigated as alternatives to the proposed OU 2 IM/IRA. These included granular media filtration with polymer addition for suspended solids removal and ion exchange for metals and radionuclide removal. In addition, UV peroxide oxidation and air stripping with off-gas treatment were examined for organic contaminant removal. Ion exchange and UV peroxide systems are proposed for treatment of contaminated ground water at the 881 Hillside Area which contain constituents which are similar to the OU 2 surface water contaminants. However, with regard to ion exchange, plutonium is not a ground water contaminant at the 881 Hillside Area, and ion exchange (or other inorganic treatment technologies) are not proven technologies for removal of plutonium from natural water. There is no appreciable difference in

environmental impacts of the alternative organic contaminant treatment technologies. The cross-flow membrane filtration system is the only proven system for removal of the targeted radionuclides.

#### 8.2.2 Personnel Exposure

The use of alternate treatment technologies would have little impact on the personnel exposure associated with surface water cleanup. The contaminants in the water remain the same and the removal techniques are essentially similar with respect to personnel exposure risk.

#### 8.2.3 Transportation

The selection of one of the other alternative treatment technologies may require different transportation requirements, dependent on the rate of water treated and the contaminants to be removed. The ion exchange columns utilize resin beads that may require periodic replacement. Using a UV peroxide treatment process would reduce transportation impacts primarily due to elimination of some of the by-product materials produced by the process. Overall, the transportation impact for this alternative is minimal.

### 8.3 SUMMARY

The impacts of the alternatives are judged to be small. The potential impacts associated with the proposed action and each of the identified alternatives are presented in Table 8-1-A and B.



TABLE 8-1-A

SUMMARY COMPARISON OF POTENTIAL IMPACTS OF  
PROPOSED ACTION AND ALTERNATIVES - RADIONUCLIDE TREATMENT

<u>Impact Category</u>	<u>Alternatives</u>		
	<u>Proposed Action</u>	<u>No Action</u>	<u>Contact Filtration/ Ion Exchange</u>
<b>ENVIRONMENTAL IMPACTS</b>			
Excavation	Negligible	None	Negligible
Topographical Deformation (Permanent)	Treatment Facility	None	Treatment Facility
Endangered Species	Negligible	None	Negligible
Wetlands	Negligible	None	Negligible
Cultural Impacts	Negligible	None	Negligible
Archaeological Impacts	Negligible	None	Negligible
Transportation	Limited	None	Limited
<b>LONG-TERM CONSIDERATIONS</b>			
Remedical Action Period (Institutional Control)	30 years	Not Applicable	30 years
VOC Contaminant Removal	No	No	No
Radionuclide Removal	Yes	No	Possibly, but unproven
Inorganic Contaminant Removal	Yes	No	Yes
<b>EXPOSURE OF GENERAL PUBLIC</b>			
Construction	Negligible	None	Negligible
Routine	Negligible	Future Release Risk	Negligible
Accident	Negligible	None	Negligible

TABLE 8-1-B

**SUMMARY COMPARISON OF POTENTIAL IMPACTS OF  
PROPOSED ACTION AND ALTERNATIVES - ORGANIC TREATMENT**

<u>Impact Category</u>	<u>Proposed Action</u>	<u>Alternatives</u>	
	<u>Activated Carbon Columns</u>	<u>No Action</u>	<u>UV Peroxide Oxide or Air Stripping</u>
<b>ENVIRONMENTAL IMPACTS</b>			
Excavation	Negligible	None	Negligible
Topographical Deformation (permanent)	Treatment Facility	None	Treatment Facility
Endangerment Species Impact	Negligible	None	Negligible
Wetlands Impact	Negligible	None	Negligible
Cultural Impacts	None	Negligible	None
Archaeological Impacts	Negligible	None	Negligible
Transportation	Limited	None	Limited
<b>LONG-TERM CONSIDERATIONS</b>			
Remedial Action Period (Institutional Control)	30 years	Not Applicable	30 years
VOC Contaminant Removal	Yes	No	Yes
Radionuclide Removal	No	No	No
Inorganic Contaminant Removal	No	No	No
<b>EXPOSURE OF GENERAL PUBLIC</b>			
Construction	Negligible	None	Negligible
Routine	Negligible	Future Release Risk	Negligible
Accident	Negligible	None	Negligible

## SECTION 9

### REFERENCES

- Burney, 1989, Burney & Associates, Inc , An Archeological and Historical Survey of Selected Parcels Within the Department of Energy, Rocky Flats Plant, North Jefferson County, Colorado, January 1989
- Cleveland, J M , 1979, The Chemistry of Plutonium, American Nuclear Society, New York
- Davis, C N , and K E Sorenson, 1969, Handbook of Applied Hydraulics, Third Edition, McGraw-Hill Company, New York
- Dixon, W J , 1953, Processing Data Outliers, Biometrics, v 9, pp 74-89
- DOE, 1980, U S Department of Energy, Final Environmental Impact Statement, Rocky Flats Plant Site, Golden, Jefferson County, Colorado, U S Department of Energy ERDA 1545-D, DOE/EIS-0064, April 1980
- DOE, 1983, Occupational Safety and Health Program for DOE Contractor Employees at Government-Owned Contractor-Operated Facilities " U S Department of Energy Order 5483 1A, June 1983
- DOE, 1984, "Environmental Protection, Safety, and Health Protection Standards " U S Department of Energy Order 5480 4, May 1984
- DOE, 1985, "Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes " U S Department of Energy Order 5480 3, July 1985
- DOE, 1986, Comprehensive Environmental Assessment and Response Program Phase 1 Draft Installation Assessment, Rocky Flats Plant, U S Department of Energy, unnumbered draft report
- DOE, 1988a, U S Department of Energy, "Internal Dose Conversion Factors for Calculation of Dose to the Public", DOE/EH-0071, Washington, D C , July 1988
- DOE, 1988b, "Radioactive Waste Management " U S Department of Energy Order 5820 2A, September 1988
- DOE, 1988c, "Comprehensive Environmental Response, Compensation, and Liability Act Requirements " DOE Draft Order 5400 YY, September 1988
- DOE, 1988d, "Radiation Protection for Occupation Workers " U S Department of Energy Order 5480 11, December 1988
- DOE, 1990a, "Federal Facility Agreement and Consent Order/Inter-Agency Agreement," U S Department of Energy, August 17, 1990
- DOE, 1990b, "Radiation Protection of the Public and the Environment " U S Department of Energy Order 5400 5, February 8, 1990
- Donaldson, James C , and Logan MacMillan, 1980, "Oil and Gas History of Development and Principal Fields in Colorado," in Colorado Geology, Harry C Kent and Karen W Porter, editors, Rocky Mountain Associations Geologists, pp 175-189
- Dow Chemical Company, 1971, Anonymous Memorandum, January 15, 1971
- DRCOG, 1989, "DRCOG Makes 1989 Estimates of Metro Population and Households" Denver Regional Council of Governments, September 1989
- EG&G, 1989, An Aerial Radiology Survey of the United States Department of Energy's Rocky Flats Plant Draft, Golden, Colorado

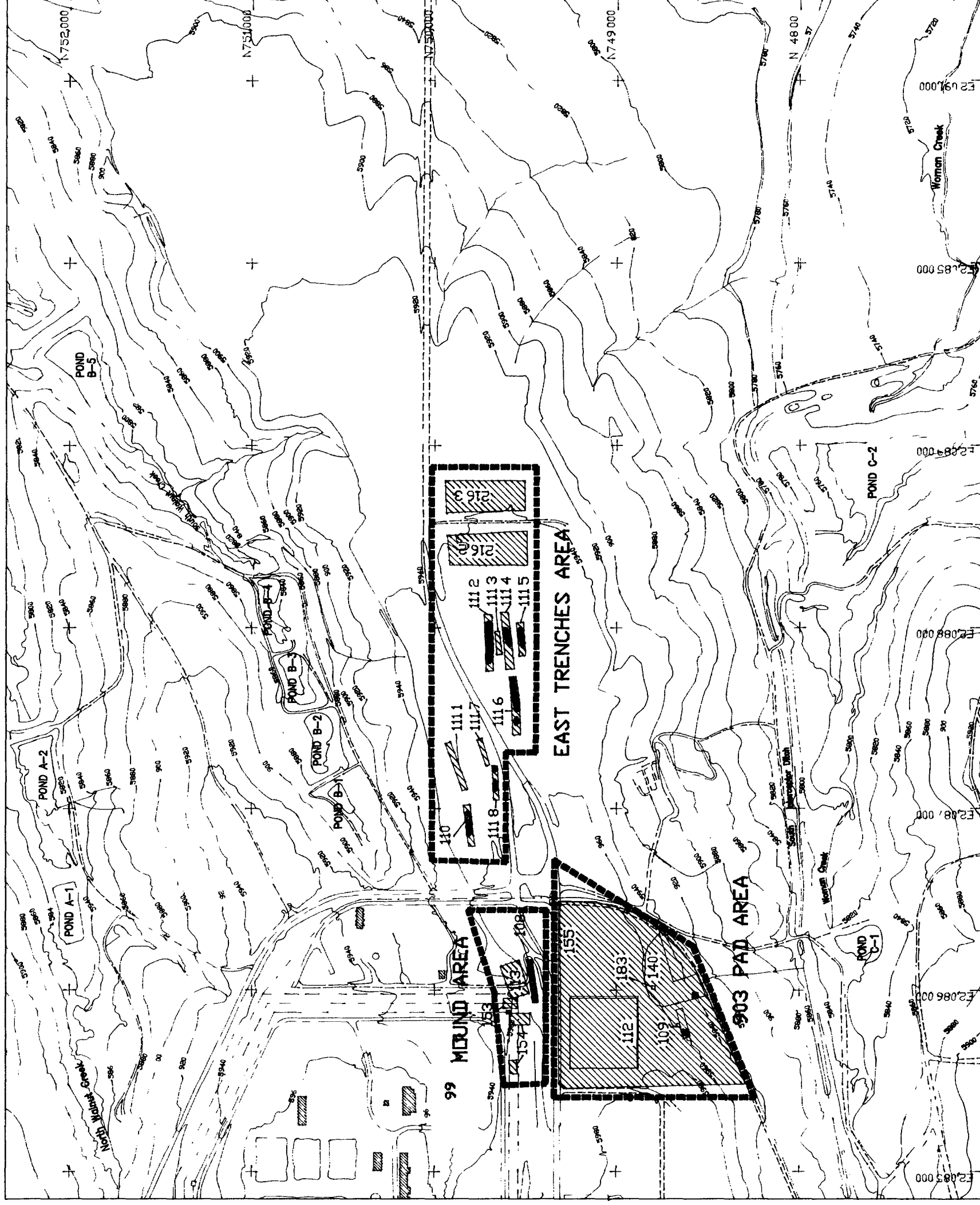
- EG&G, 1990a, "Phase II RFI/RIFS Workplan, Final, Operable Unit No 2, 903 Pad, Mound and East Trenches Area, April, 1990
- EG&G, 1990b, "Wetlands Assessment, Rocky Flats Site", prepared by ASI for EG&G, Lakewood, Colorado, April 1990
- EPA, 1985, Compilation of Air Pollutant Emission Factors Volume I Stationary Point and Area Sources, PB86-124906, Research Park, NC, September 1985
- EPA, 1988, U S Environmental Protection Agency, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion and Ingestion", EPA-520/1-88-020, Washington, D C , September 1988
- EPA, 1989a, Risk Assessment Guidance For Superfund, Volume 1 Human Health Evaluation Manual (Part A), EPA/540/1-89/002, December 1989
- EPA, 1989b, Health Effects Assessment Summary Tables, Fourth Quarter FY 1989, OERR 9200 6-303-(89-4), October, 1989
- EPA, 1990, "Technology Evaluation Report Site Program Demonstration of the Ultrox International Ultraviolet Radiation/Oxidation Technology", EPA-540/5-89/012, Cincinnati, Ohio, January 1990
- Gifford, F A , Jr , 1961, Use of Routine Meteorological Observations For Estimating Atmospheric Dispersion, Nuclear Safety 2(4) 47-57, 1961
- Gifford, F A , Jr , 1976, Turbulent Diffusion - Type Schemes A Review, Nuclear Safety 17(1) 68-86, February, 1976
- Hetzer, H W , 1987, "Continuous Upflow Filtration," American Water Works Association, Pennsylvania Section Meeting, May 6, 1987
- Hurr, R T , 1976, Hydrology of a Nuclear-Processing Plant Site, Rocky Flats, Jefferson County, Colorado, U S Geological Survey Open-File Report 76-268
- Illsley, C T , 1978, Memorandum to M V Werkema, Rockwell International entitled "Briefing on Burial Trenches," December 19, 1978
- LeRoy, L W , and R J Weimer, Geology of the Interstate 70 Road Cut, Jefferson County, Colorado, Colorado School of Mines Prof Contrib No 7
- Orlandini, K A , Penrose, W R , Harvey, B R , Lovett, M B , Findlay, M W , "Colloidal Behavior of Actinides in an Oligotrophic Lake, Environmental Science and Technology, Volume 24, No 5, 1990
- Post, P , 1989, Personal Communication, U S D A , Colorado Agricultural Statistics Service, November 1989
- Puls, R W and M J Barcelona, 1989, Ground-Water Sampling For Metals Analyses EPA Superfund Ground-Water Issue, EPA/540/4-89/0001
- Rao, R K , E L Wilmot, and R E Luna, "Non-Radiological Impact of Transporting Radioactive Materials," SAND 81-1703, TTC-0236, Albuquerque, NM, Sandia National Laboratories, 1982
- Robson, S G , J C Romero, and S Zawistowski, 1981a, Geologic Structure, Hydrology and Water Quality of the Arapahoe Aquifer in the Denver Basin, Colorado U S Geological Survey Atlas HA-647
- Robson, S G , A Wacinski, S Zawistowski, and J C Romero, 1981b, Geologic Structure, Hydrology, and Water Quality of the Laramie Fox Hills Aquifer in the Denver Basin, Colorado U S Geological Survey Hydrologic Atlas HA-650

- Rockwell International, 1986a Resource Conservation and Recovery Act Part B - Operations Permit Application for U S DOE Rocky Flats Plant, Hazardous and Radioactive Mixed Wastes, U S Department of Energy, unnumbered report
- Rockwell International, 1987a Draft Remedial Investigation Report for 903 Pad, Mound, and East Trenches Areas U S Department of Energy, Rocky Flats Plant, Golden, Colorado
- Rockwell International, 1987b, Resource Conservation and Recovery Act Part B - Operating Permit Application for U S DOE Rocky Flats Plant, Hazardous and Radioactive Mixed Wastes, Revision 1, U S Department of Energy, unnumbered report
- Rockwell International, 1988a, Draft Remedial Investigation Plan for 903 Pad, Mound, East Trenches Areas, Phase II Sampling Plan, U S Department of Energy, Rocky Flats Plant, Golden, Colorado, June 30, 1968
- Rockwell International, 1988b Draft Feasibility Study Report for High Priority Sites (881 Hillside Area) March 1988
- Rockwell International, 1988c Annual Environmental Monitoring Report Rocky Flats Plant January through December 1988
- Rockwell International 1988d Letter from George Campbell to Albert E Whiteman, Rocky Flats Area Office re Endangered Species at the Rocky Flats Plant July 15, 1988
- Rockwell International, 1989a, Report of Chromic Acid Leak from Building 444 Acid Rinse Waste Tank System, Rocky Flats Plant, Golden, Colorado March 29, 1989
- Rockwell International, 1989b, Draft Interim Measures/Interim Remedial Action Plan and Decision Document for 903 Pad, Mound and East Trenches Area, U S Department of Energy, Rocky Flats Plant, Golden Colorado December, 1989
- Rockwell International 1989c, Quality Assurance/Quality Control Plan Environmental Restoration Program, Rocky Flats Plant, January 1989
- Rockwell International, 1989d, Background Geochemical Characterization Report U S Department of Energy, Rocky Flats Plant, Golden, Colorado December 15, 1989
- Sax N I and R J Lewis 1987, Hawley's Condensed Chemical Dictionary, Eleventh Edition Van Nostrand Reinhold Company, New York
- Scott, G R 1960 Quaternary Faulting and Potential Earthquakes in East-Central Colorado U S Geological Survey, Prof Paper 700-C pp C11-C18
- Slade, D H (ed), 1968 Meteorology and Atomic Energy - 1968, TID-24190, U S Atomic Energy Commission/Division of Technical Information
- Smith R E , 1975, Memorandum to D J Cockeram, Rockwell International, Rocky Flats Plant on Buried Radioactive Material, September 2, 1975
- Sorg, T J 1987 "Review of Treatment Methods for Removal of Uranium from Drinking Water," AWWA Annual Conference Seminar, Kansas City, Missouri, June 1987
- Tiepel E W and J Shorr 1985, "Applications of Advanced Membrane Filtration to Industrial Wastewater Treatment and Groundwater Clean-up," International Water Conference, 46th Annual Meeting, November 4-7 1985
- Weber W A G Kunkel, and L. Schultz, 1974, A Botanical Inventory of the Rocky Flats Atomic Energy Commission Site, Final Report, University of Colorado, Boulder, Colorado report COO-2371-2


INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)  
AND IHSS DESIGNATION

LOCATION OF BARRELS DETERMINED BY  
VISUAL INSPECTION OR MAGNETOMETER  
SURVEY

REMEDIAL INVESTIGATION AREAS



Scale 1" = 600'



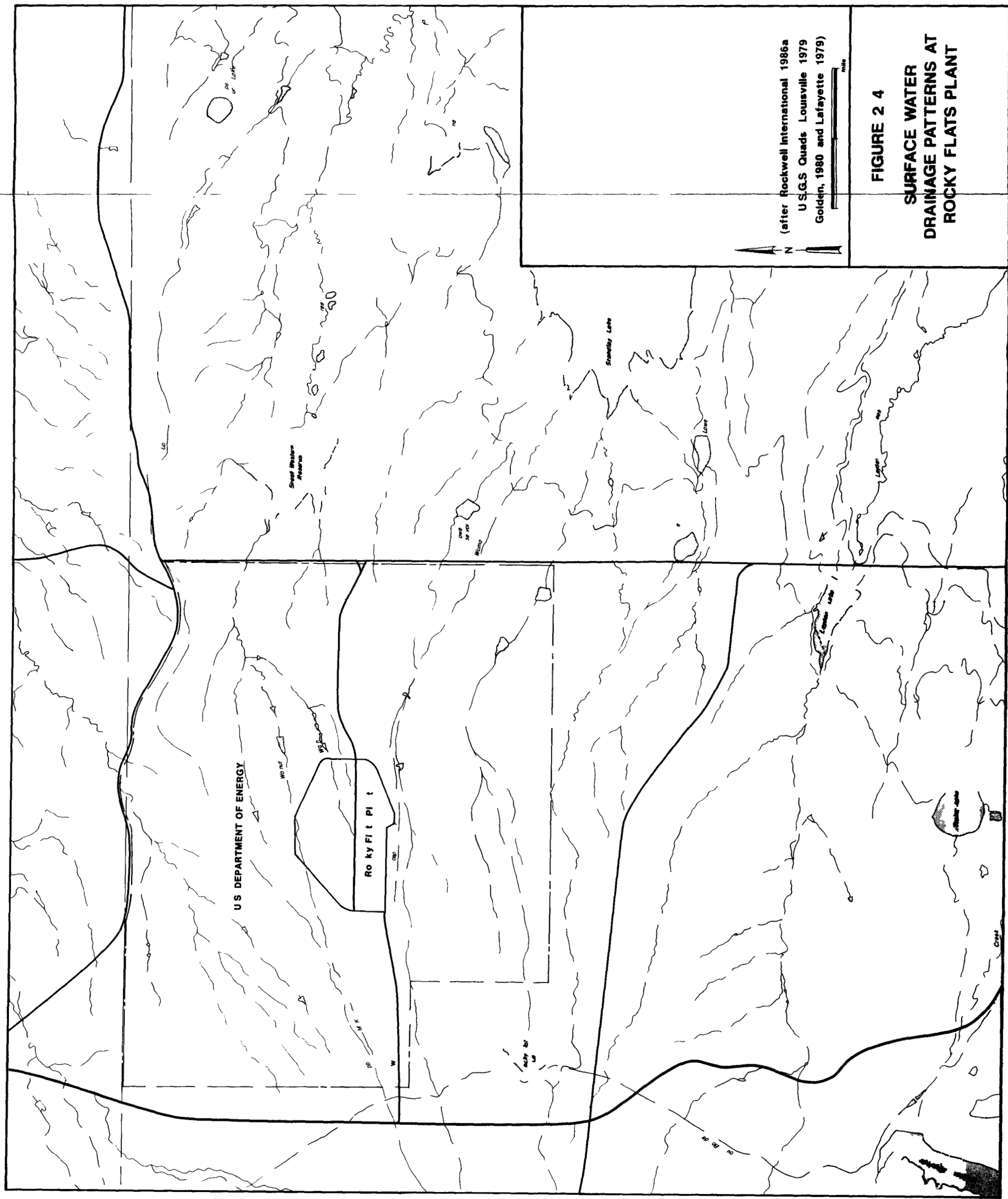
CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY  
Rocky Flats Plant  
Golden Colorado

OPERABLE UNIT NO 2  
SURFACE WATER IM/IRA

**FIGURE 2-2**

# REMEDIAL INVESTIGATION AREAS AND INDIVIDUAL HAZARDOUS SUBSTANCE SITES



**FIGURE 2 4**  
**SURFACE WATER**  
**DRAINAGE PATTERNS AT**  
**ROCKY FLATS PLANT**

EXPLANATION



INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)

5798

POTENTIOMETRIC SURFACE ELEVATION (feet above mean sea level)

ALL DATA BASED ON MEASUREMENTS MADE APRIL 4-8 1988 INCLUSIVE

LINE OF EQUAL POTENTIOMETRIC SURFACE ELEVATION (feet above mean sea level)-DASHED WHERE APPROXIMATELY LOCATED

5880

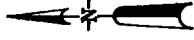
ND

NO DATA

2587 ● BEDROCK MONITOR WELL

3789 ○ ALLUVAL MONITOR WELL

03882 ▲ PRE-1988 MONITOR WELL



Scale 1" = 600'



CONTOUR INTERVAL = 20'

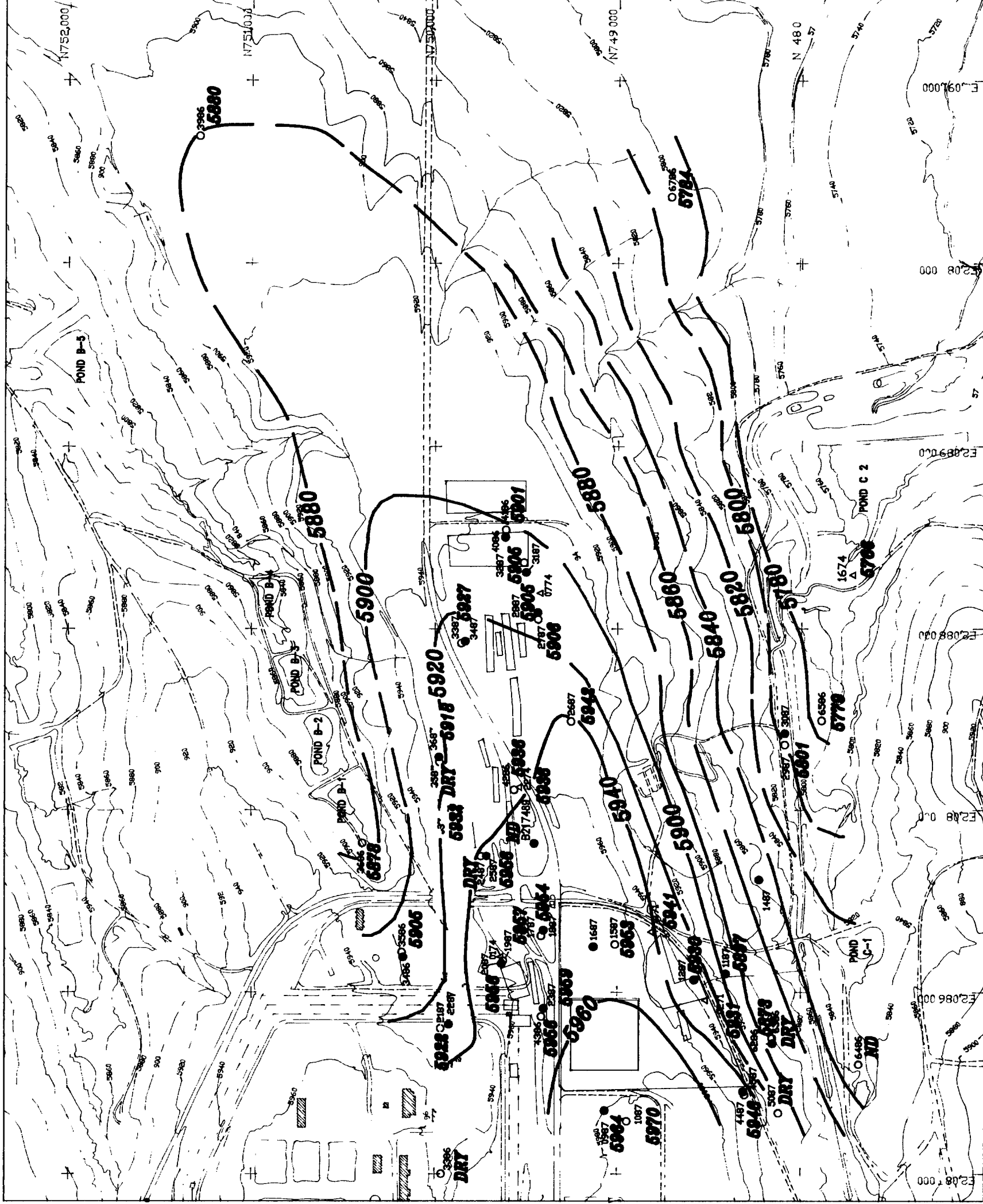
U S DEPARTMENT OF ENERGY  
Rocky Flats Plant  
Golden Colorado

OPERABLE UNIT NO 2  
SURFACE WATER IM/IRA

FIGURE 2-7

POTENTIOMETRIC SURFACE OF THE UNCONFINED GROUND-WATER FLOW SYSTEM

August 1990





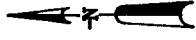
EXPLANATION

INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)

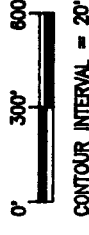
LINE OF EQUAL  $\text{CCl}_4$  CONCENTRATION ( $\mu\text{g/l}$ )  
DASHED WHERE APPROXIMATELY LOCATED

NOTE: DATA VALUES SHOWN ON TABLE A 5

- 2587 ● BEDROCK MONITOR WELL
- 3789 ○ ALLUVIAL MONITOR WELL
- 0382 ▲ PRE-1986 MONITOR WELL



Scale 1" = 600'



CONTOUR INTERVAL = 20'

U S DEPARTMENT OF ENERGY  
Rocky Flats Plant  
Golden Colorado

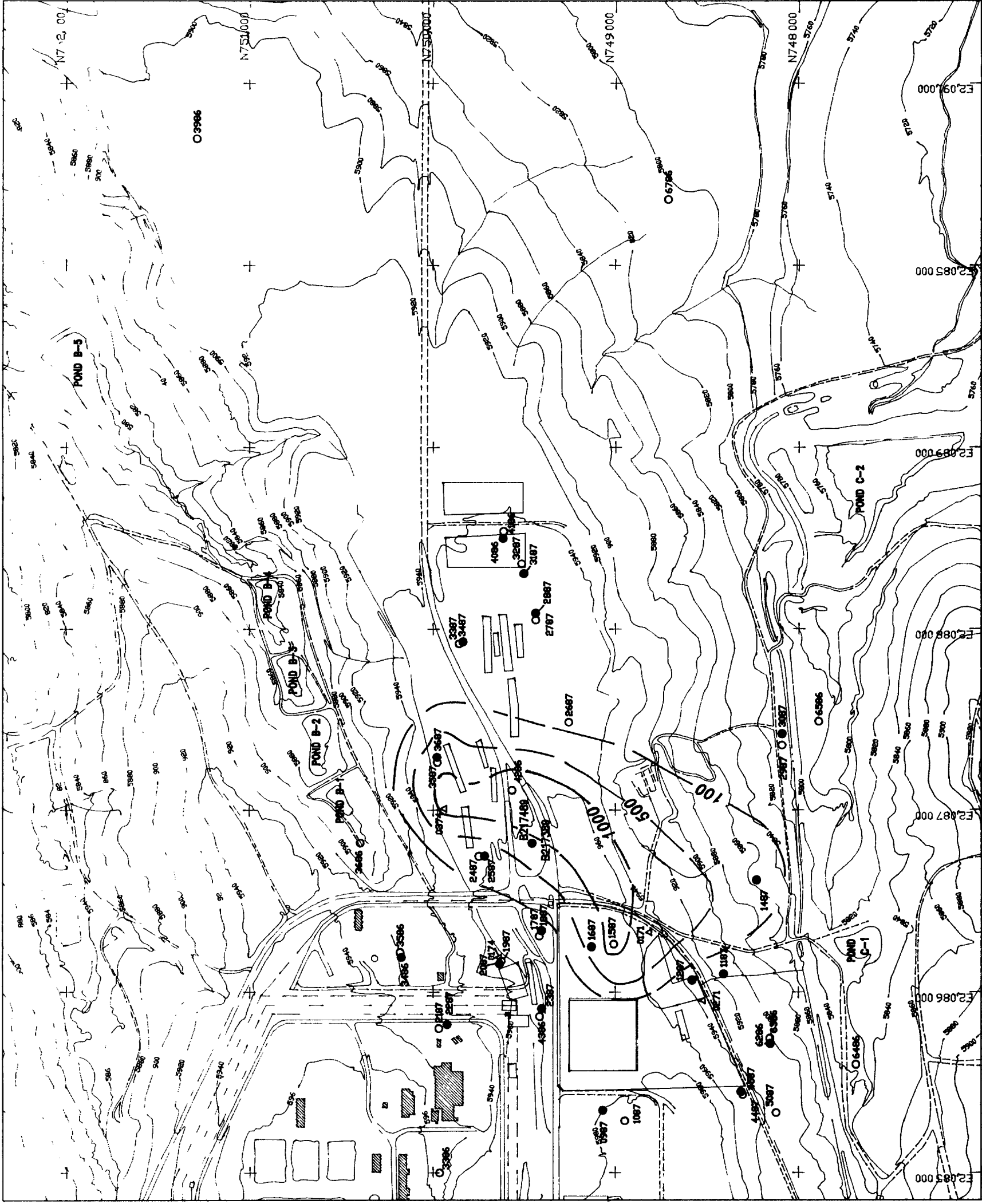
OPERABLE UNIT NO 2  
SURFACE WATER IM/IRA

FIGURE 2-8

CARBON TETRACHLORIDE ISOPLETHS  
FOR THE UNCONFINED GROUND-WATER  
FLOW SYSTEM

Second Quarter 1989

August 1990



EXPLANATION



INDIVIDUAL HAZARDOUS SUBSTANCE SITE (HSS)

-500-

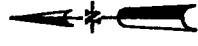
LINE OF EQUAL PCE CONCENTRATION ( $\mu\text{g/l}$ )  
DASHED WHERE APPROXIMATELY LOCATED

NOTE: DATA VALUES SHOWN ON TABLE Q4-5

2587 ● BEDROCK MONITOR WELL

3789 ○ ALLUVIAL MONITOR WELL

0382 ▲ PRE-1986 MONITOR WELL



Scale 1" = 600'

0' 300' 600'  
CONTOUR INTERVAL = 20'

U S DEPARTMENT OF ENERGY  
Rocky Flats Plant  
Golden Colorado

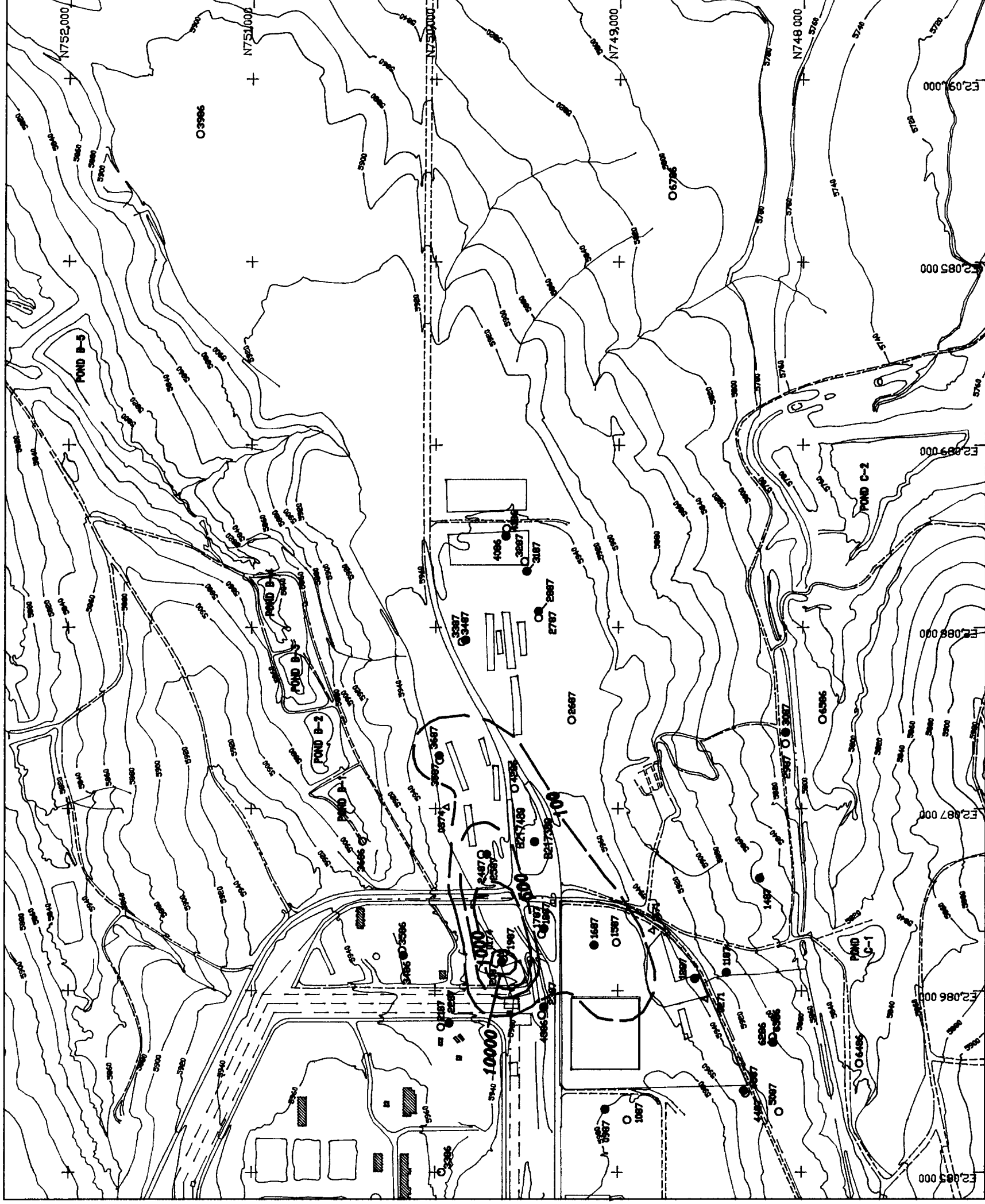
OPERABLE UNIT NO 2  
SURFACE WATER IM/IRA

FIGURE 2-9

TETRACHLOROETHENE ISOPLETHS  
FOR THE UNCONFINED GROUND-WATER  
FLOW SYSTEM

Second Quarter 1989

August 1990



EXPLANATION



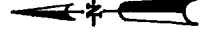
INDIVIDUAL HAZARDOUS SUBSTANCE  
SITE (IHSS)



LINE OF EQUAL TCE CONCENTRATION ( $\mu\text{g/l}$ )  
DASHED WHERE APPROXIMATELY LOCATED

NOTE: DATA VALUES SHOWN ON TABLE A 5

- 2587 ● BEDROCK MONITOR WELL
- 3789 ○ ALLUVIAL MONITOR WELL
- 0382 ▲ PRE-1986 MONITOR WELL



Scale 1" = 600'  
0' 300' 600'  
CONTOUR INTERVAL = 20'

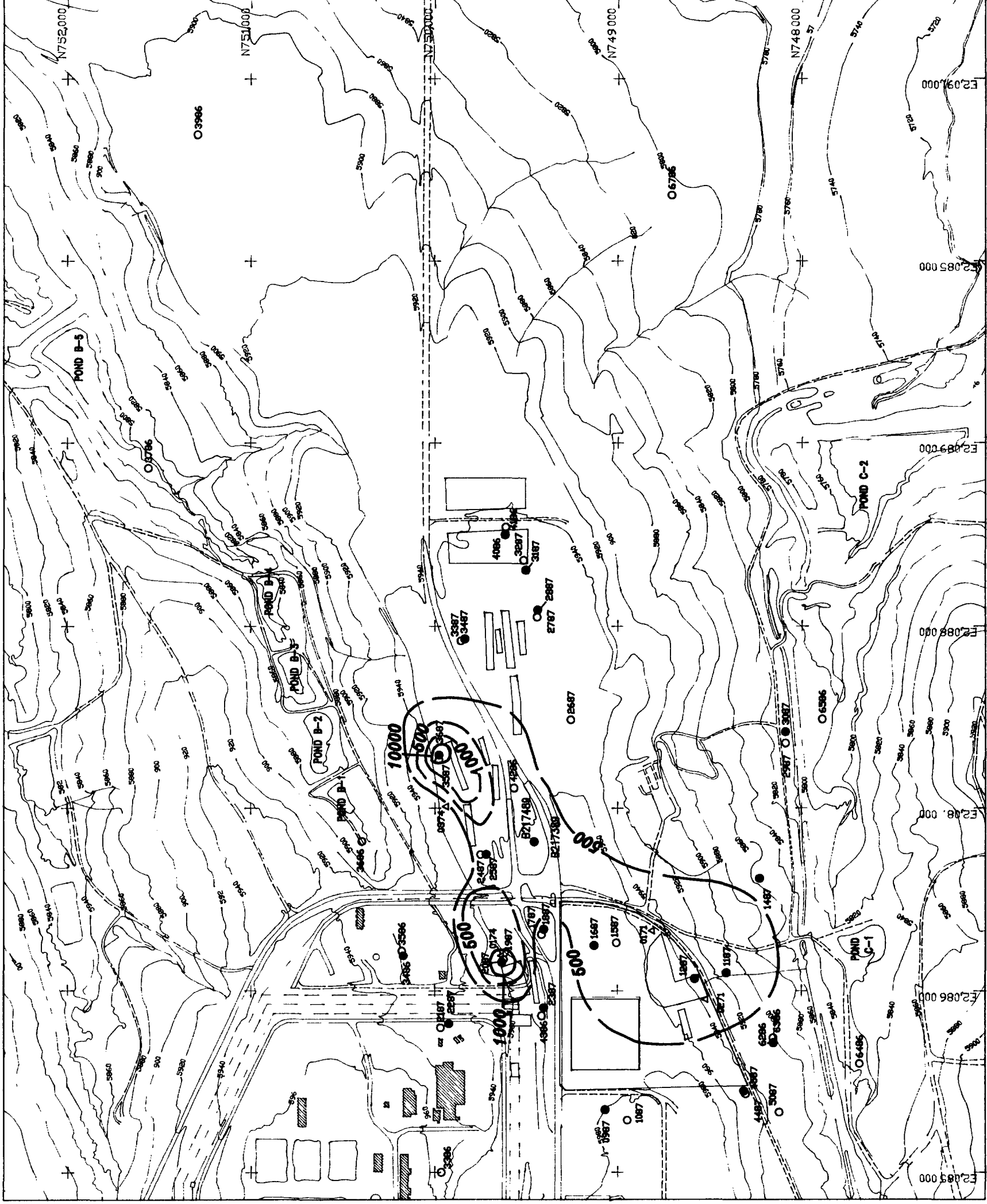
U S DEPARTMENT OF ENERGY  
Rocky Flats Plant  
Golden, Colorado

OPERABLE UNIT NO 2  
SURFACE WATER IM/IRA

FIGURE 2-10

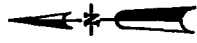
TRICHLOROETHENE ISOPLETHS  
FOR THE UNCONFINED GROUND-WATER  
FLOW SYSTEM  
Second Quarter 1989

August 1990



EXPLANATION

- INDIVIDUAL HAZARDOUS SUBSTANCE SITE (IHSS)
- SURFACE WATER MONITORING STATION SW-23
- SURFACE WATER MONITORING STATION SED-13



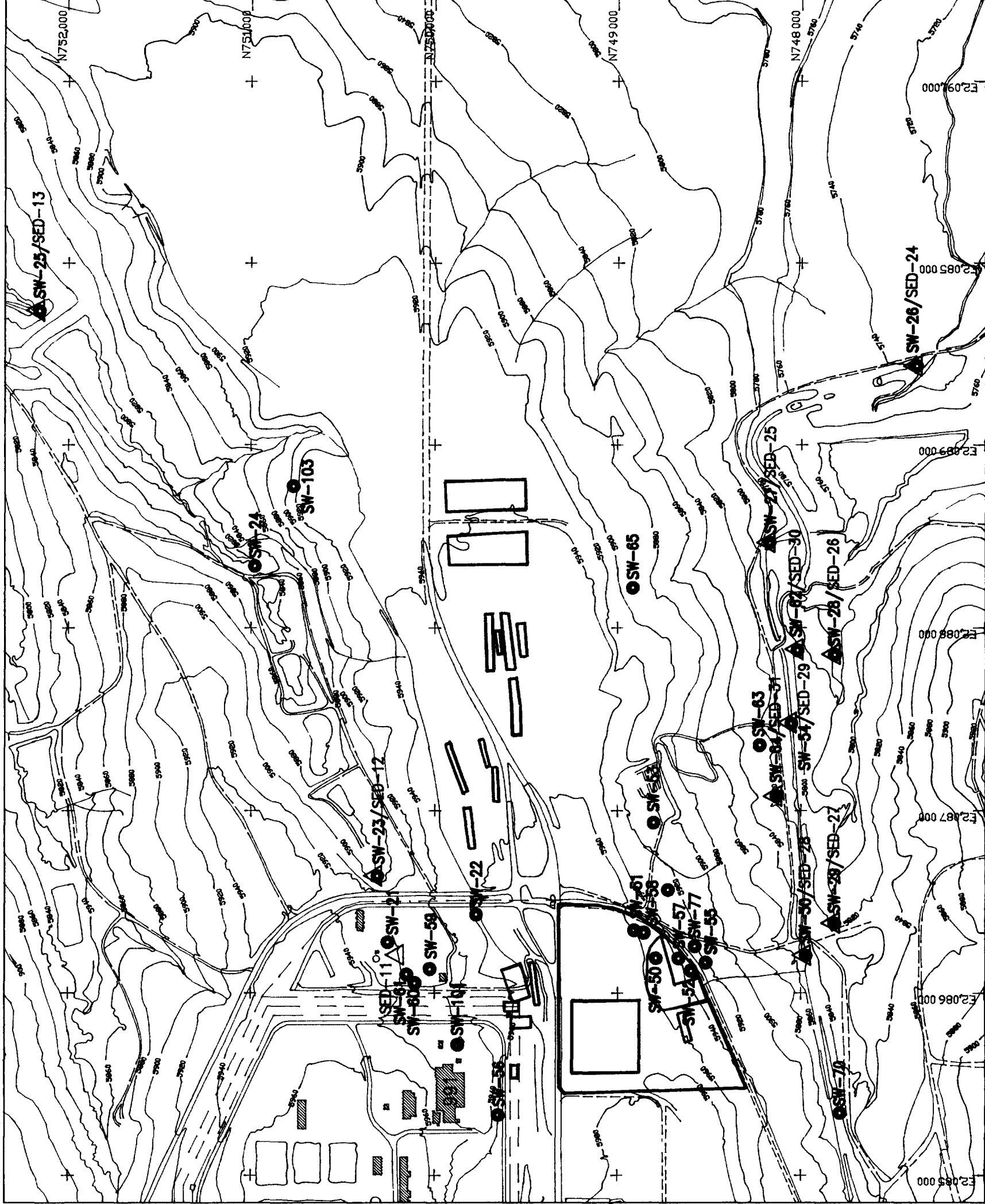
Scale 1" = 600'  
0' 300' 600'  
CONTOUR INTERVAL = 20'

U S DEPARTMENT OF ENERGY  
Rocky Flats Plant  
Golden, Colorado

OPERABLE UNIT NO 2  
SURFACE WATER IM/IRA

FIGURE 2-11

SURFACE WATER AND SEDIMENT  
MONITORING STATIONS



EXPLANATION



INDIVIDUAL HAZARDOUS SUBSTANCE  
SITE (IHSS)



SURFACE WATER MONITORING STATION  
AT A SURFACE SEEP



SURFACE WATER MONITORING STATION  
IN A SURFACE WATER DRAINAGE



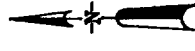
IM/IRA SURFACE WATER MONITORING  
STATION AT A SURFACE SEEP



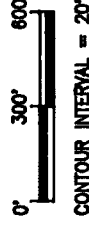
IM/IRA SURFACE WATER MONITORING  
STATION IN A SURFACE WATER DRAINAGE



IM/IRA SURFACE WATER MONITORING  
STATION AT THE EXIT OF A CULVERT



Scale 1" = 600'



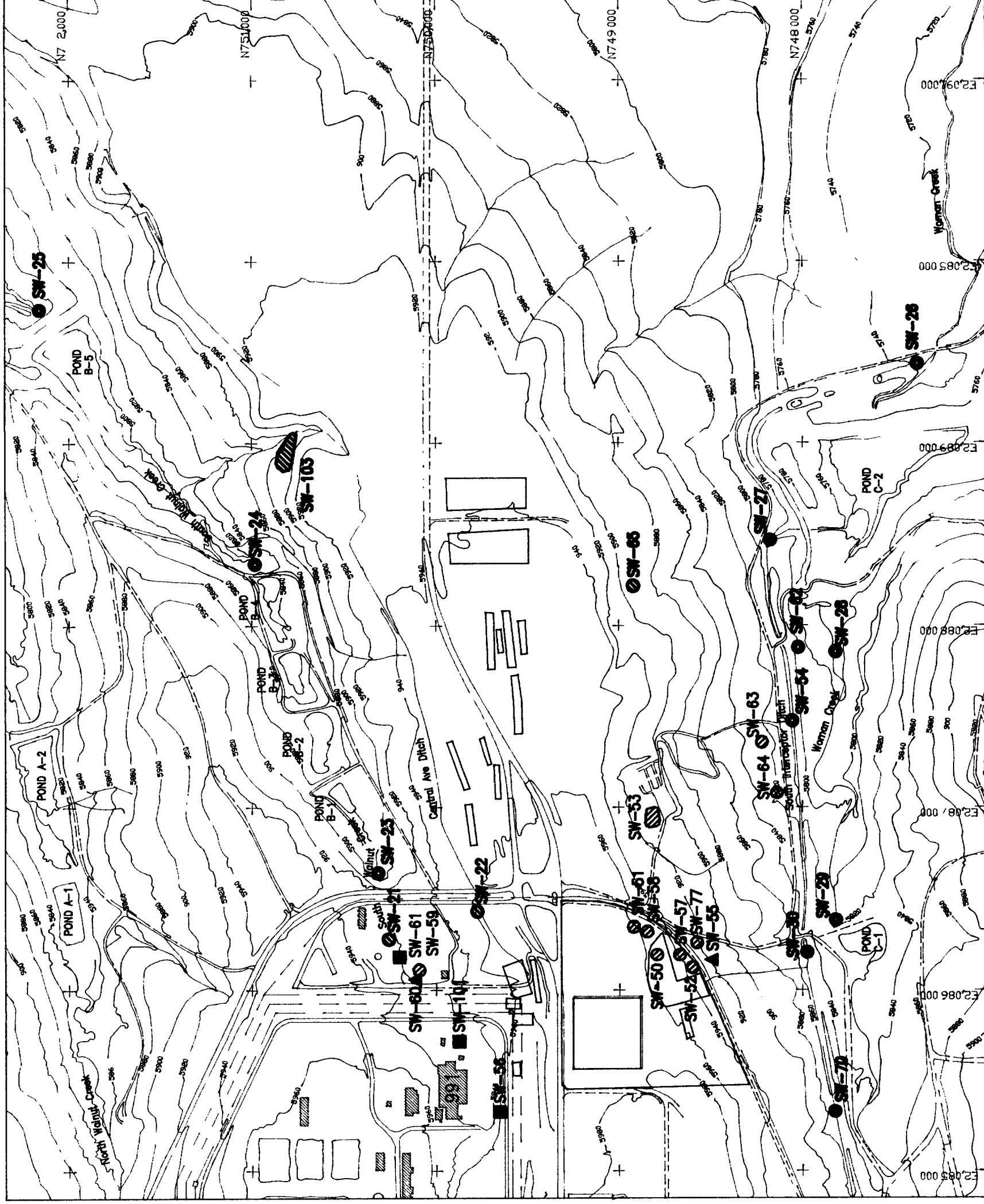
U S DEPARTMENT OF ENERGY  
Rocky Flats Plant  
Golden Colorado

OPERABLE UNIT NO. 2  
SURFACE WATER IM/IRA

FIGURE 4-1

SURFACE WATER  
MONITORING STATIONS

August 1980

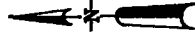




EXPLANATION

- IM/IRA SURFACE WATER MONITORING STATION AT A SURFACE WATER SEEP
- IM/IRA SURFACE WATER MONITORING STATION IN A SURFACE WATER DRAINAGE
- IM/IRA SURFACE WATER MONITORING STATION AT THE EXIT OF A CULVERT
- SURFACE WATER DIVERSION AND COLLECTION SYSTEM
- SURFACE WATER TRANSPORT TO TREATMENT SYSTEM BY TRUCK
- SURFACE WATER TRANSPORT TO TREATMENT SYSTEM BY PIPELINE
- SURFACE WATER TREATMENT SYSTEM EFFLUENT DISCHARGE

- SW-59
- SW-61
- SW-55
- CS-61



Scale 1" = 600'

0' 300' 600'

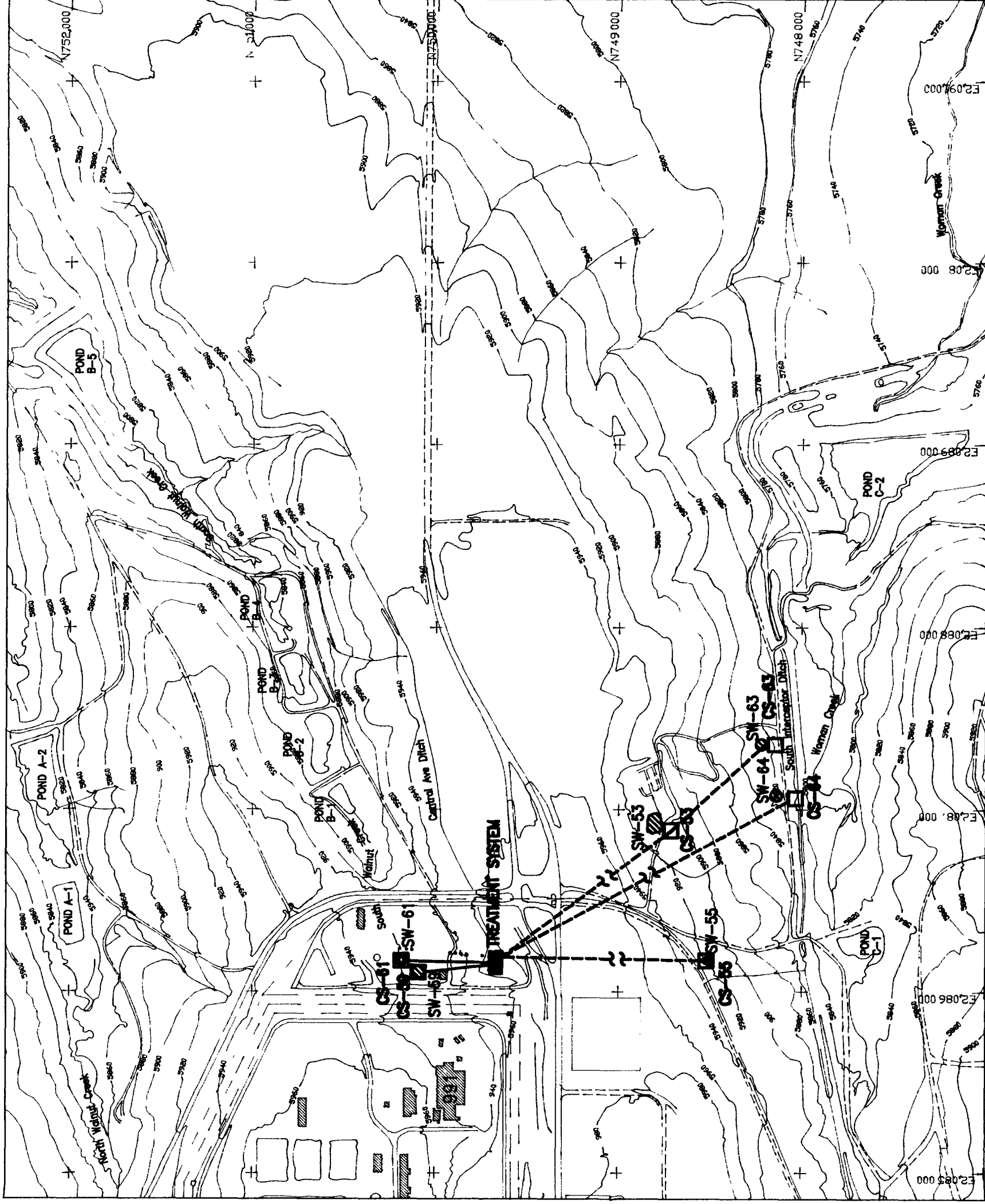
CONTOUR INTERVAL = 20'

U S DEPARTMENT OF ENERGY  
Rocky Flats Plant  
Golden Colorado

OPERABLE UNIT NO 2  
SURFACE WATER IM/IRA

FIGURE 4-3

LOCATION OF PROPOSED SURFACE  
WATER COLLECTION AND  
TREATMENT FACILITIES



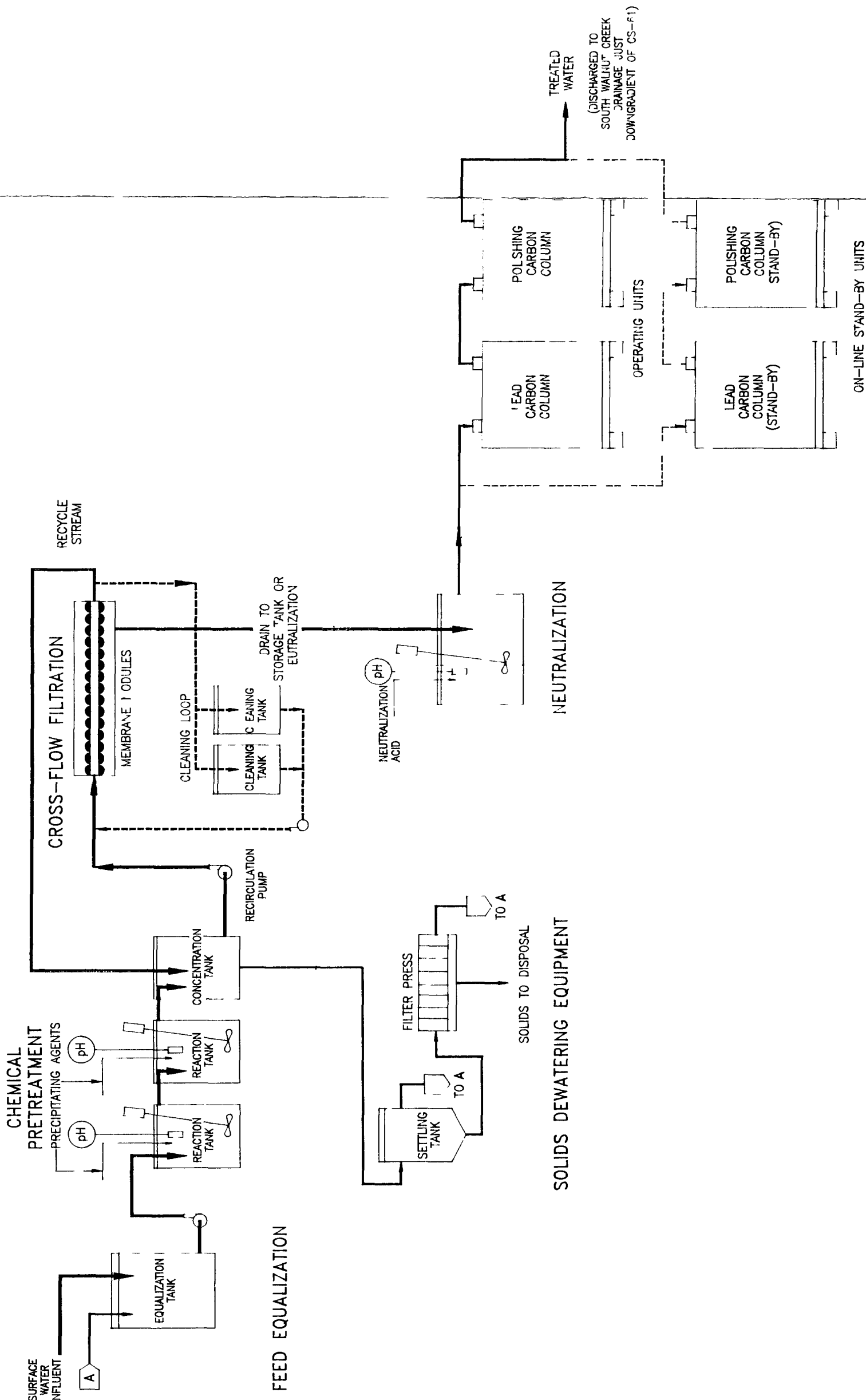


FIGURE 6-1

PROPOSED IM/IRA TREATMENT SYSTEM  
PROCESS FLOW DIAGRAM